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DEPARTMENT OF MINES, MINING AND GEOLOGY

GARLAND PEYTON, Director

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Bulletin No. 61

GEOLOGY OF THE STONE MOUNTAIN-LITHONIA DISTRICT, GEORGIA

By

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LETTER OF TRANSMITTAL

Department of Mines, Mining and Geology

Atlanta, April 15, 1954

To His Excellency, Herman E. Talmadge, Governor

Commissioner Ex-Officio of State Division of Conservation

Sir:

I have the honor to submit herewith Georgia Geological Survey Bulletin No. 61, "Geology of the Stone Mountain—Lithonia District, Georgia".

This report was prepared by Dr. Leo A. Herrmann as a Doctor's thesis in geology at The Johns Hopkins University. It represents a thorough and original investigation of one of Georgia's most important granite districts. Thus, its publication will be welcomed by our granite producers and by all who are interested in the science of granite.

Very respectfully yours,

Garland Peyton

GARLAND PEYTON
Director

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ABSTRACT

The rocks of the Stone Mountain-Lithonia District are weathered to a red or brown saprolite except for portions of the Lithonia gneiss and Stone Mountain granite which form monadnocks. Stone Mountain is the most prominent monadnock in the area.

The metamorphic rocks of the district have been deformed into northwest trending transverse folds which are perpendicular to a regional northeast trending axis of uplift. A pronounced mica lineation, the axes of small folds, and elongated garnet porphyroblasts are parallel to the axes of the transverse folds. Two sets of shear zones were developed in the Lithonia gneiss during deformation; a pronounced set trends about N20°E and a less pronounced set trends about N40°W.

The Stone Mountain granite (quartz-monzonite) intruded the Lithonia gneiss and the metamorphic rocks. Flow structures were developed in the Stone Mountain granite during its intrusion. These include flowage foliation, mica fluctuation about an axis of rotation, and parallel orientation of micaceous autoliths.

The Lithonia gneiss was highly migmatized by concordant, syntectonic aplite intrusions which altered the rock into a biotite granite-gneiss. Relic bedding remains in the rock in the form of quartz-rich garnetiferous layers which are usually conformable with the gneissic banding.

Amphibolite layers are conformable with the banding of the enclosing gneisses. The amphibolites have the composition of meladiorite, but show no evidence of intrusive origin. They are probably either volcanic or sedimentary in origin.

The metamorphic rocks of the district were regionally metamorphosed to the level of the staurolite-kyanite subfacies of the amphibolite facies. In addition, the rocks immediately surrounding the Lithonia gneiss were progressively metamorphosed to the level of the sillimanite-almandine subfacies. The boundary between the two subfacies is marked by the change from epidote to diopside in the amphibolites.

The age of the metamorphic rocks is considered to be pre-Cambrian. The Lithonia gneiss was apparently migmatized

during or shortly after the final deformation of the metamorphic rocks. This deformation may have taken place in the early stages of the Appalachian Revolution. Perhaps during a late stage of the Appalachian orogeny, the Stone Mountain granite (Permian?) was intruded. Diabase dikes were intruded in Triassic time along northwesterly trending breaks.

The last two sections of the report describe the stone industry and quarries of the district.

GEOLOGY OF THE STONE MOUNTAIN-LITHONIA DISTRICT, GEORGIA

INTRODUCTION

PURPOSE OF THE REPORT

This report has been written to add to the store of geologic information concerning the Georgia Piedmont. A short history of the stone industry and a section describing the quarries of the district are also included in order to bring up to date the information contained in the comprehensive report by Watson on **The Granites and Gneisses of Georgia** (1902).

LOCATION OF THE DISTRICT

The Stone Mountain-Lithonia district lies between 33° 37′ 23″ and 33° 50′ north latitude, and 84° 01′ 20″ and 84° 10′ west longitude. The geologic map (Plate 1) covers an area

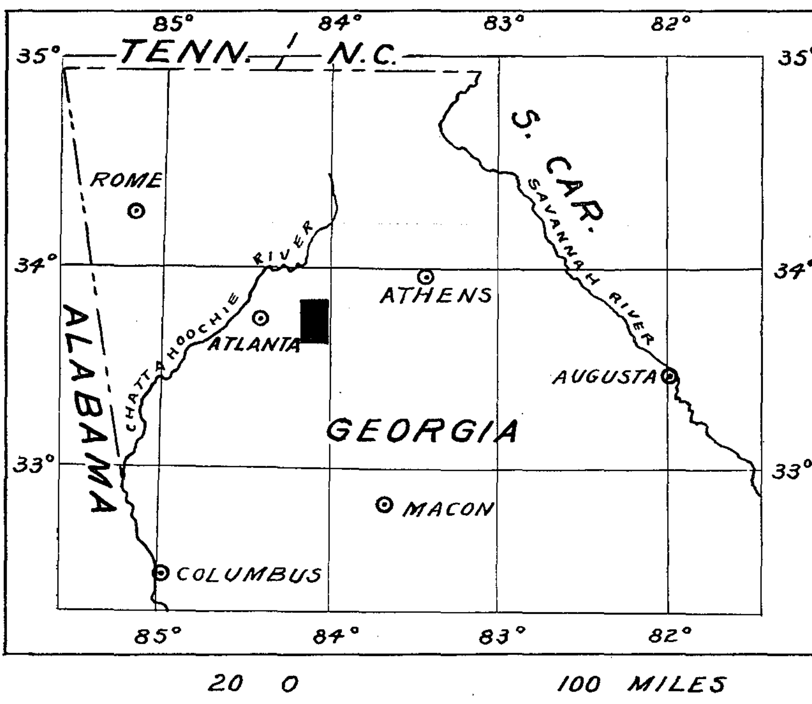

Fig. 1. Index map showing location of the Stone Mountain-Lithonia District.

of approximately one hundred square miles, located fourteen miles east of Atlanta (Fig. 1). It includes the eastern portion of DeKalb County, the southwestern portion of Gwinnett County, and the western portion of Rockdale County.

The district can be reached by U. S. Route 78 which enters the area at Stone Mountain, and by Georgia Route 12 which enters the district about five miles west of Lithonia. The Georgia Railroad traverses the area between Stone Mountain and Conyers.

PHYSIOGRAPHY

The northwest and southeast portions of the Stone Mountain-Lithonia district are located, respectively, in the Atlanta plateau and the Midland slope division of the Central Upland physiographic province as defined by La Forge (1925, p. 16). They are part of the broader Appalachian Piedmont which extends from New York to Alabama.

Stone Mountain (Fig. 2), a monadnock of the Atlanta plateau, rises from an elevation of approximately 1000 feet above sea level at its base to 1686 feet at its peak. It is a roughly elliptical mass of granite one and one-half miles

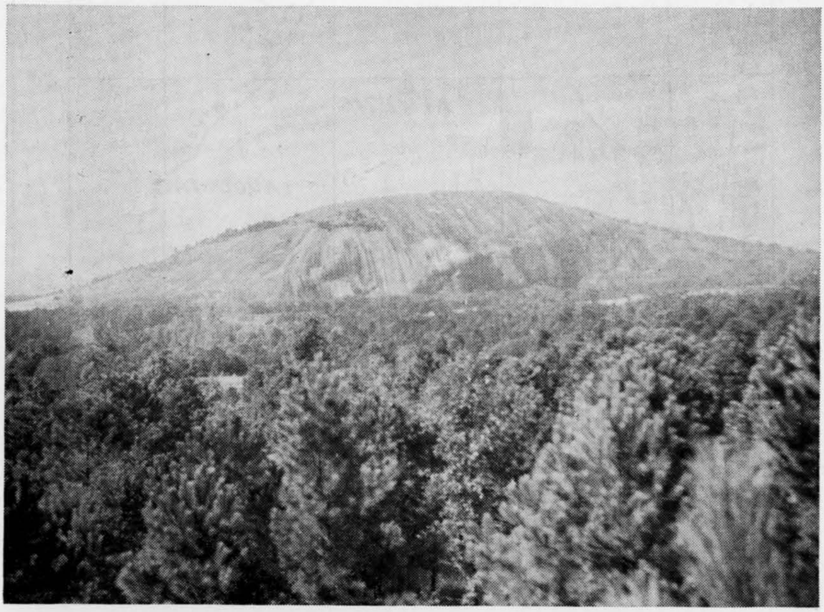

Fig. 2. Stone Mountain viewed from the northeast.

long whose major axis trends N70°W. It has a gentle western slope, a steep to vertical northeast slope, and eastern and southern slopes which range from 10°-35°.

Several monadnocks in the vicinity of Lithonia rise from 50 to 200 feet above the surrounding plain. Rock Chapel Mountain is located six miles S50°E of Stone Mountain; and Little Stone Mountain, locally known as Pine Mountain, is located one mile east of Lithonia. Arabia Mountain consists of two distinct masses which lie three miles south of Lithonia. Two smaller masses occur on either side of Arabia Mountain; the eastern one is known as Bradley Mountain, and the elongated western one is known as Mile Rock.

Many smaller residual pavements* of Lithonia gneiss and Stone Mountain granite occur in the district. The larger ones have been outlined on Plate 1 and Plate 8. The monadnocks and pavements are nearly devoid of vegetation, with only occasional pine and cedar trees growing in joint cracks. Because of the mosses and lichens on their surfaces, the rocks have a dull gray appearance when viewed from a distance.

The area is drained by a dendritic stream pattern; the streams to the east of Stone Mountain and Little Stone Mountain are tributaries of Yellow River, and those to the west and south of Stone Mountain are tributaries of South River.

The steams are largely sluggish, with gentle gradients. Many have few, if any, rock exposures, whereas others have continual rapids for several miles. In general, the streams draining the southwest portion are aggrading and contain extensive deposits of alluvium.

The development of broad meanders and oxbow lakes in Yellow River southeast of Rock Chapel Mountain, and the presence of numerous rapids along the river west of Centerville, indicate that the stream profile has not reached equilibrium. The fluvial cycle is probably one of maturity.

WEATHERING

Deep, residual weathering produces a thick red mantle in which original structures such as banding and schistosity are often preserved. For this type of mantle, Becker (1894-95,

*Pavement is a general term for all nearly flat or gently sloping exposures of hard rock.

p. 289) proposed the term saprolite "as a general name for thoroughly decomposed, earthy, but untransported rock". The bedrock beneath the mantle is seldom exposed except in stream beds and large residual pavements.

The Lithonia gneiss forms a light gray to nearly red saprolite.

The garnet-mica schist forms a red, very micaceous saprolite in which the schistosity is preserved, even in rock almost entirely converted to clay. The muscovite quartzite seldom forms a saprolite except where it contains several per cent of feldspar; in such cases it readily disintegrates to a kaolin-bearing sand.

The hornblende gneisses (amphibolites) produce the most distinctive type of saprolite. They weather to a red to brown clay (Fig. 3) which has a smooth feel when rubbed between the fingers. Frequently the clay merges gradually into hard, dark green hornblende gneiss.

Porphyroblastic biotite gneiss and biotite-hornblende gneiss

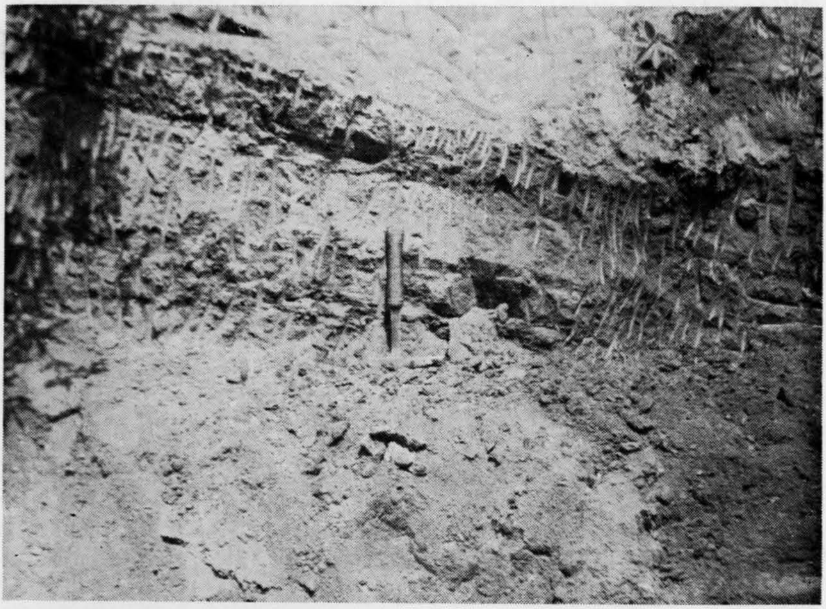

Fig. 3. Amphibolite layers in biotite gneiss, weathered to saprolite.

weather to reddish colored saprolites which are often mottled with purple.

Stone Mountain granite forms a white, structureless saprolite which contains disseminated muscovite flakes.

A zone of partially weathered, iron-stained "sap" forms a cover four to six inches deep on pavements of hard bedrock of Lithonia gneiss and Stone Mountain granite. A characteristic of the nearly flat pavements is the occurrence on them of horizontally floored, rounded pits of depressions. These weathering pits range from several feet in diameter and several inches deep to tens of feet in diameter and several feet deep. The floors of the pits are almost always covered with a thin veneer of sandy, gray to black soil which supports a small growth of mosses and lichens. The pits are usually unrelated to any visible structure, although a few are found at the intersection of joint planes with the surface.

The origin of weathering pits was discussed by Smith (1941, pp. 117-127). He found that standing waters in the

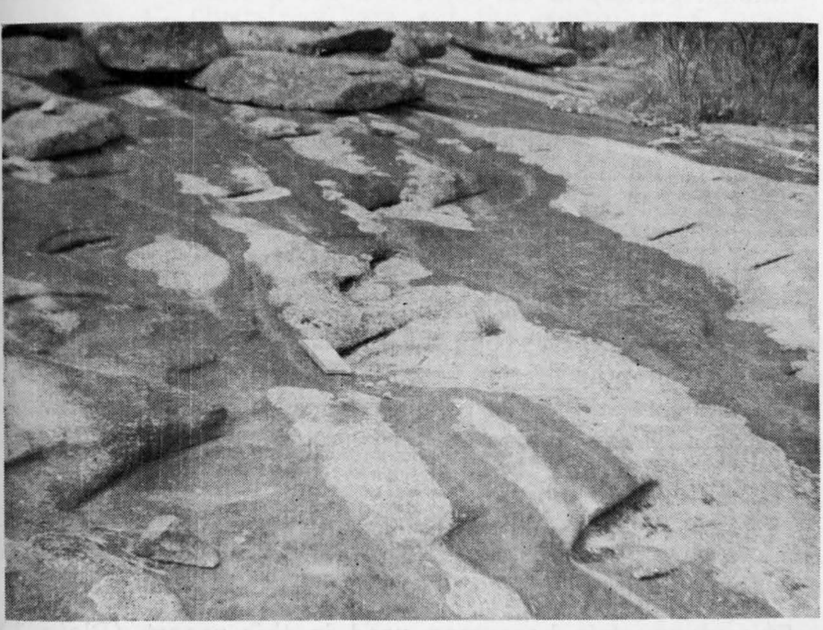

Fig. 4. Elliptical weathering pits on the surface of Stone Mountain. Dark bands due to straining. Note book gives scale.

depressions were acidic, with pH readings ranging from 5.0-5.4. He concluded that the basins were initiated in slight depressions produced by spalling. Chemical weathering is accelerated by the presence of acidic water (produced by plant action) which breaks down the component minerals, especially feldspars. The sandy residuum is removed by rain water and wind action.

A second type of weathering pit occurs on the flanks of Stone Mountain. These pits are small, elliptically shaped depressions which are aligned parallel to the flow structure of the granite. Figure 4 illustrates typical examples.

PREVIOUS WORK

C. W. Purington (1894, pp. 106-108) described Stone Mountain as an eruptive laccolite which owes its present form to its original intrusive shape. Several years later, T. L. Watson (1902) included a petrographic description of the Stone Mountain granite and the Lithonia contorted granite-gneiss (Lithonia gneiss) in his report on the granites and gneisses of Georgia. He made no geologic map of the area.

The last detailed work done in the area was by J. G. Lester who made a petrographic study of the granites and gneisses of the region in 1938. The geology of the area was mapped by reconnaissance in 1939 by G. W. Crickmay.

PRESENT STUDY

Geologic mapping of the district was begun in the summer of 1949 and completed at the end of September, 1950. A total of 7½ months were spent in the field. The writer spent about two months of the first field season making detailed pace and compass maps of quarries in the Stone Mountain granite and Lithonia gneiss.

Aerial photographs were used as control for geologic mapping. The only available topographic map of the area, the Atlanta sheet, surveyed in 1887-1888 (revised, 1895) was of no value in a detailed study because of its small scale.

The planimetric base map used in this report (Plate 1) was drafted by the writer from a compilation of Fairchild Aerial Surveys photographs (1939-40 flight). Control for the photographs was obtained from the "25,000 foot grid computed from 'Transverse Mercator Projection Tables for Georgia' "* of the respective counties included in the map.

ACKNOWLEDGMENTS

The writer is indebted to the Department of Mines, Mining and Geology of the State of Georgia for payment of field expenses. Captain Garland Peyton, Director, and Dr. A. S. Furcron, chief geologist of the Department of Mines, gave much helpful advice in the office and in the field.

Dr. Ernst Cloos, under whose direction the research was undertaken, spent several days in the field with the writer and made many helpful suggestions on the interpretation of the complex structures of the district. Dr. J. L. Anderson reviewed and gave helpful criticism of the section on petrogenesis; and Dr. R. W. Chapman, Dr. Byron Thomas and Mr. R. J. Pickering critically read the manuscript.

Dr. J. D. Ryan and Mr. H. J. Werner helped prepare the photomicrographs and photographs of rock specimens.

Mr. W. C. Overstreet laid out the control grid for the geologic base map.

Acknowledgment is also made to Mr. Nelson Severinghaus of the Consolidated Quarry Corporation, the Davidson Brothers of the Davidson Granite Co., Mr. G. A. Coffey of the Coffey Granite Co., and Messrs. Arthur Kellogg and Otis King of the Kellogg Granite Co., who gave the writer information on production figures, quarrying methods, and historical background of the stone industry. Major Lee Brantley, retired quarry operator, gave the writer information on most of the non-operating quarries of the district.

Finally, the writer is indebted to many others who helped make this report possible.

*Official highway maps of Gwinnett, Rockdale, and DeKalb Counties, Georgia. State Highway Department of Georgia, 1948.

PETROGRAPHY

MIGMATITE

Lithonia Gneiss

General statement—The Lithonia gneiss was first described in detail by Watson (1902) in a report on the granites and gneisses of Georgia. He named it the Lithonia contorted granite gneiss (1902, p. 127) on the basis of its structure and chemical composition. Crickmay (1939) revised the name to Granite gneiss, Lithonia type, apparently because of the non-contorted appearance of the gneiss in areas other than the type locality, Lithonia. The rock is called Lithonia gneiss in this report and is classified as a migmatite on the basis of its physical and chemical characteristics.

Extensive quarrying from 1890 to 1951 has yielded many fresh exposures of Lithonia gneiss. Twelve quarries were mapped in detail by pace and compass. Several of these maps are reproduced in this report to show the most typical structures of the gneiss.

Distribution—The Lithonia gneiss underlies the northeast and southeast portions of the map area (Plate 1), forming the southwest extension of a large body of biotite gneiss more than 80 miles long and 20 miles wide, elongated in a northeasterly direction (Geologic Map of Georgia, 1939).

Megascopic character—The Lithonia gneiss is a light gray, evenly banded gneiss which contains characteristic pink garnetiferous layers (Figure 5) at several localities. The garnetiferous layers range in thickness from several inches to several feet. The rock is highly folded and sheared, and individual shear zones are filled with white aplite or pegmatite dikes.

The rock is medium-grained and extremely hard. A gray-white color is imparted by concentration of light and dark colored minerals into alternating bands ranging in thickness

Fig. 5. Garnetiferous layer within the Lithonia gneiss at Little Stone Mountain, faulted and offset several feet.

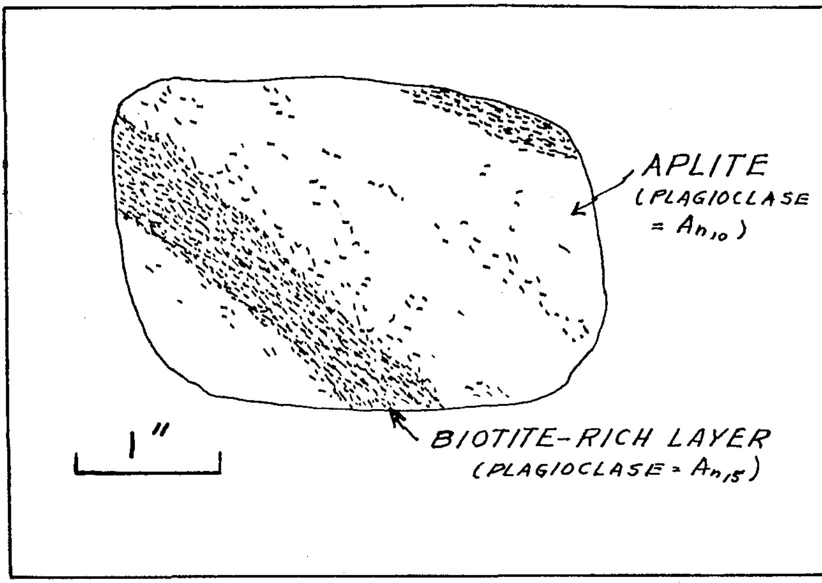

Fig. 6. Aplite layer (vein) parallel to biotite-rich band. Collinsville Mountain, south of Little Stone Mountain. Sketched on polished surface.

from one-tenth to one-half inch. Aplite is commonly concentrated into layers parallel to biotite-rich bands composed of quartz, oligoclase (An_{15}), biotite, and accessory microcline (Figure 6).

Microscopic character—Thin sections of evenly banded gneiss show an indistinct biotite foliation. The microscopic texture is xenoblastic and slightly inequigranular. The groundmass grains range in size from 0.1 mm to 1.0 mm, and large oligoclase and microcline grains range in size from 1.0 mm to 5.0 mm. Grain boundaries are irregular and frequently serrate, with mutual embayment of quartz and oligoclase. Replacement textures are common; symplectitic muscovite (Sederholm, 1916, p. 131) replaces oligoclase (Figure 7), and microcline replaces oligoclase (Figure 8). Many of the oligoclase and microcline grains are poikiloblastic, containing small, globular inclusions of quartz with random optical orientation.

The garnetiferous layers have a granoblastic groundmass containing small porphyroblasts of garnet. The quartz-oligoclase grain boundaries are irregular to polyhedral. Garnet is

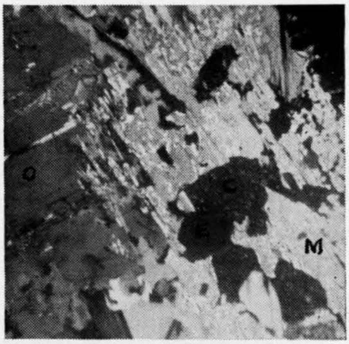

Fig. 7. Muscovite replacing oligoclase with associated epidote and calcite. Crossed nicols. X40.

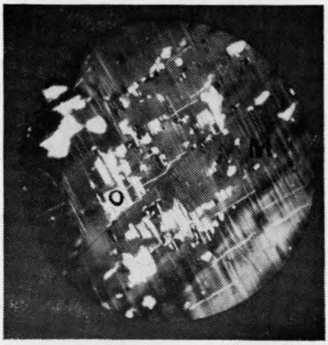

Fig. 8. Microcline replacing oligoclase. Crossed nicols. X15.

found in all stages of growth from incipient, irregular grains replacing oligoclase and quartz to euhedral garnet porphyroblasts (Figure 9).

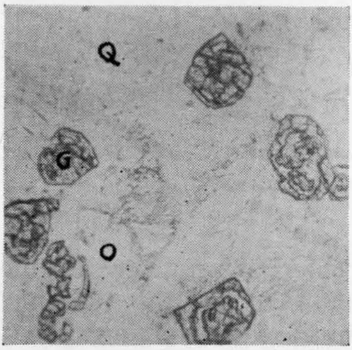

Fig. 9. Garnet porphyroblasts replacing quartz and oligoclase. Parallel light. X40.

The mineral paragenesis, based on a study of grain boundaries in 15 thin sections, is as follows: Zircon and apatite → biotite → globular quartz → oligoclase → irregular (large) quartz → symplectitic muscovite → microcline.

The mineralogical compositions of the various rock types which constitute the Lithonia gneiss are shown in Table 1. In addition to these, scolecite and fluorite are sometimes found on joint surfaces.

The composition of the plagioclase of the gneiss was determined by plotting the indices of refraction of cleavage flakes on the curves of Tsuboi (1923, Plate 1) and was substantiated by the Rittman zone method (Emmons, 1943, pp. 115-133). The concordant aplite veins or bands (Figure 6) contain oligoclase with a composition of An_{10}. The plagioclase of the biotite-rich bands is An_{15}-An_{17} and that of the garnetiferous layers is An_{16}. The well banded biotite gneiss phase contains plagioclase with a range in composition from An_9-An_{14} and an average composition of An_{12}. Secondary albite (Figure 10) is found at the borders of oligoclase in contact with microcline.

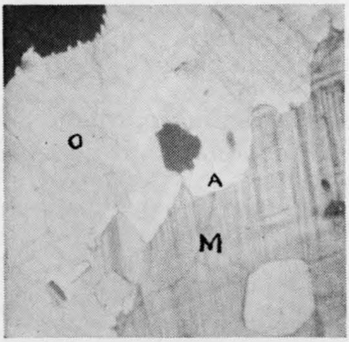

Fig. 10. Secondary albite at boundary of oligoclase and microcline. Crossed nicols. X40.

The change in composition from the biotite-rich phase to the evenly banded phase of the Lithonia gneiss is accompanied by a drop in the total weight percentage of plagioclase and a reduction of the anorthite content of the plagioclase. This relationship is shown in Figure 11.

TABLE 1

Modes of the Several Rock Types Constituting the Lithonia Gneiss in Weight Percent

Sample No.

Mineral	L4(c)	L6	L21(1)	L22(16)	L23(5)	S150(4)	S150(5)
Quartz	37.5%	37.7%	36.3%	29.5%	28.8%	21.8%	47.5%
Oligoclase	29.9(An_{14})	33.3(An_{12})	27.0(An_{11})	23.0(An_{11})	24.3(An_{10})	54.2(An_{17})	35.2(An_{16})
Microcline	25.4	23.3	31.8	44.0	44.7	4.7	......
Biotite	4.5	5.2	2.8	2.2	0.9	16.3	3.0
Muscovite	2.7	0.5	1.7	0.4	0.8	2.5	2.0
Epidote	X	X	X	0.4	X	0.5	2.9
Garnet	......	......	0.4	......	......	......	9.4
Magnetite	X	X	X	0.5	0.5	X	X
Pyrite	......	X	......	......	......	......	......
Sphene	......	......	......	......	......	......	X
Apatite	X	X	X	X	X	......	......
Zircon	X	......	X	X	......	X	X
Calcite	X	X	X	......	......	X	X
Chlorite	......	......	......	X	......	X	X
Sericite	X	X	X	X	X	......	X
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

X—Trace

Location of Samples in Table 1

L4(C)—Evenly banded biotite gneiss from a small quarry on the east side of the Lithonia-Klondike Highway, located 2700 yards S13°W of Lithonia.

L6—Evenly banded biotite gneiss from the Forest Lake quarry, located 700 yards north of Forest Lake.

L21(1)—Evenly banded biotite gneiss (with flow folded banding) from the A. G. Wilson quarry, located one mile north of Lithonia on the west side of the Stone Mountain-Lithonia Highway.

L22(16)—Evenly banded biotite gneiss from the Davidson quarry, one mile north of Lithonia.

L23(5)—Concordant aplite vein from Collinsville Mountain, 1000 yards south of Little Stone Mountain.

S150(4)—Biotite-rich band within the Lithonia gneiss from the Snell Johnson quarry west of Little Stone Mountain.

S150(5)—Garnetiferous layer from the Snell Johnson quarry west of Little Stone Mountain.

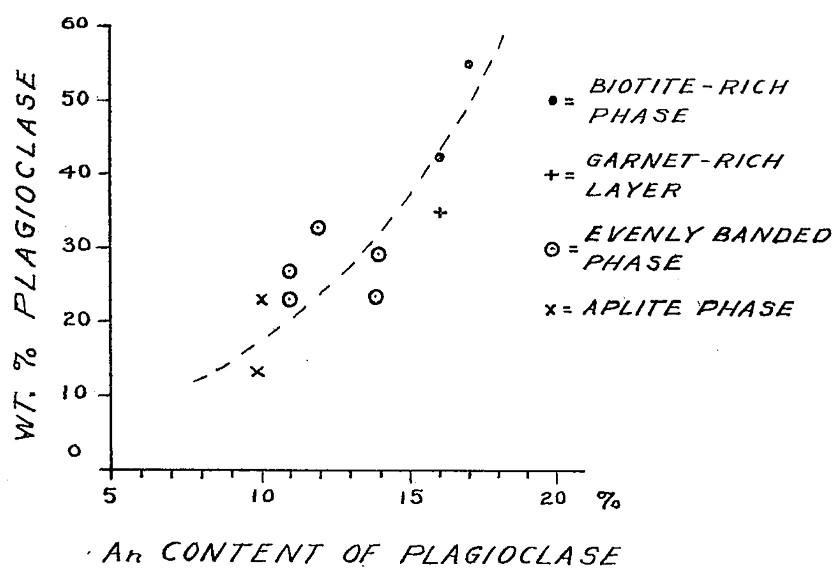

Fig. 11. Range in weight percentage and anorthite content of plagioclase from various phases of the Lithonia gneiss.

Microcline is seldom seriticized or altered in any way.

Biotite is pleochroic: X = Straw yellow < Y = dark brownish green < Z = dark green. Nα ranges from 1.582-1.593 (± .002) and Nγ ranges from 1.636-1.646 (± .002) The average composition (Winchell 1951, Fig. 257) is 45% annite, 45% phlogopite, 5% siderophyllite, and 5% eastonite.

Secondary muscovite replaces oligoclase and biotite. It is colorless and non-pleochroic. (—) 2V = 36°-41°. Nβ = 1.602 (± .002) and Nγ = 1.608 (± .002). The composition (Winchell, 1951, Figure 254) is approximately 35% muscovite, 42% picrophengite, and 23% ferrimuscovite.

Garnet is pink in hand specimens and colorless in thin sections. Its index of refraction is 1.80 (± .005) and its specific gravity, determined on a Berman microbalance, is 3.914. The composition cannot be determined from these data since they fall on three separate diagrams of Kennedy (1947, Figure 9, b, e, and h).

Epidote is largely secondary, replacing oligoclase and occasionally biotite. It is colorless to light brown and slightly pleochroic in thin section. (—)2V = 80° (± 3°). Nβ = 1.750 (± .005). Its composition (Winchell, 1951, Figure 343) is 75% $HCa_2Al_3Si_3O_{13}$ and 25% $HCa_2Fe_3Si_3O_{13}$.

Scolecite (a zeolite) has a hardness of 4.5. It is biaxial negative (2V not determined) and length fast. X $\wedge$ C = 14°. Polysynthetic twinning is common parallel to $\{100\}$. Nα = 1.510 (± .002) and Nβ = 1.516 (± .002). Its composition is $CaSi_3Al_2O_{10}.3H_2O$ (Winchell, 1951, p. 341).

Heavy mineral residue, obtained from panning Lithonia gneiss saprolite in a stream, contained two varieties of zircon, viz., well-developed crystals with prism and bipyramidal faces, and rounded ellipsoids. Both varieties were colorless to slightly brown. Colorless clinozoisite with the following optical properties was found in the residue: (+)2V = 4° ±; Nβ = 1.720 (± .002). Magnetite and ilmenite were very abundant.

METAMORPHIC ROCKS

General Statement

The gneisses and schists structurally overlying the Lithonia gneiss were formerly subdivided as Brevard schist and Carolina gneiss on the Geologic Map of Georgia (1939). The Brevard schist included garnet-mica schist and muscovite quartzite, and the Carolina gneiss included all of the remaining gneisses and schists of the area. Amphibolite bands and layers within the Carolina gneiss were called Roan gneiss by

Lester (1938) because of their apparent similarity to that formation in other areas. However, for reasons given below, purely lithologic names are substituted in this report for the terms Brevard schist, Carolina gneiss, and Roan gneiss.

The garnet-mica schist and muscovite quartzite are not considered to be Brevard schist because they do not fit the original definition given by Keith (1907, p. 4). He described the Brevard schist as a blue to black graphitic schist and slate with interbedded quartzite, conglomerate and marble.

The name Carolina gneiss is a very loose term meaning different things to different authors. Darton and Keith (1901, p. 2), originators of the name, defined it as a thick series of alternating layers of biotite gneiss and schist whose individual bands are several inches to several feet wide. LaForge and Phalen (1913, p. 4) described the Carolina gneiss as an "immense series of interbedded mica gneiss, mica schist, quartz schist, garnet schist, conglomerate, kyanite-graphite schist, and fine granitoid layers". Finally, Jonas (1932, p. 236) considered the Carolina gneiss to be the southwestward extension of the Wissahickon biotite gneiss and schist of Virginia.

A name such as Carolina gneiss with a broad range of meanings cannot be used satisfactorily in a detailed geologic study to correlate rocks of unknown geologic age in widely separated areas. Nor can the amphibolites of the district be called Roan gneiss, for unlike the Roan gneiss which "appears to cut the Carolina gneiss" (Keith, 1907, p. 3), they are concordant and conformable with respect to the compositional banding of the enclosing gneisses and schists.

The metamorphic rock series is divided into six mappable units: (1) garnet-mica schist and muscovite quartzite with occasional layers of amphibolite and biotite gneiss, (2) medium-grained biotite gneiss, (3) muscovite-quartz schist, (4) amphibolite, (5) biotite-hornblende gneiss, and (6) porphyroblastic biotite gneiss. The amphibolite includes three lithologic types based on mineralogy: pyroxene-hornblende gneiss, epidote-hornblende gneiss, and talc-actinolite-chlorite schist. The porphyroblastic biotite gneiss includes six additional minor rock types which are too local in extent to be placed on the geologic map.

Distribution

The garnet-mica schist and muscovite quartzite structurally overlie the Lithonia gneiss and form ridges which rise from 50 to 100 feet above the surrounding plain. In the area north of Rock Chapel Mountain the quartzite forms only one ridge, but west of Lithonia it forms two ridges. One and one-half miles S30°W of Lithonia it forms three distinct ridges (Plate 1).

Medium-grained biotite gneiss structurally overlies the muscovite quartzite in the areas north of Rock Chapel Mountain and northwest of Centerville. It forms a well defined syncline within the porphyroblastic biotite gneiss in the area between Rock Chapel Mountain and Centerville. Muscovite-quartz schist crops out intermittently along a small ridge 3000 yards north of Rock Chapel Mountain. The schist forms a broad, northwest trending syncline in this area. A local band of muscovite-quartz schist is located about a mile and three-quarters north of Redan.

Amphibolite which forms large and small layers and lenses within the porphyroblastic biotite gneiss can be used to outline the structural pattern of the gneisses if no other well-defined marker layers are present. A northwesterly trending synclinal basin of amphibolite is located just north of Centerville. A series of synclines and anticlines in the porphyroblastic biotite gneiss west of Lithonia are emphasized by the presence of large and small bands of amphibolite.

Biotite-hornblende gneiss forms several broad layers within the porphyroblastic biotite gneiss in the area four and one-half miles southeast of Stone Mountain village. About one mile northwest of Bermuda the gneiss seems to grade into amphibolite. The porphyroblastic biotite gneiss occupies the remainder of the area underlain by gneisses.

Garnet-mica schist and muscovite quartzite

General statement—The garnet-mica schist and muscovite quartzite are grouped together as a formation which includes small to large layers of amphibolite, biotite gneiss, quartz-muscovite schist, biotite schist and biotite quartzite. These layers are usually thin and non-mappable, but occasionally the amphibolite layers are as much as two miles long and

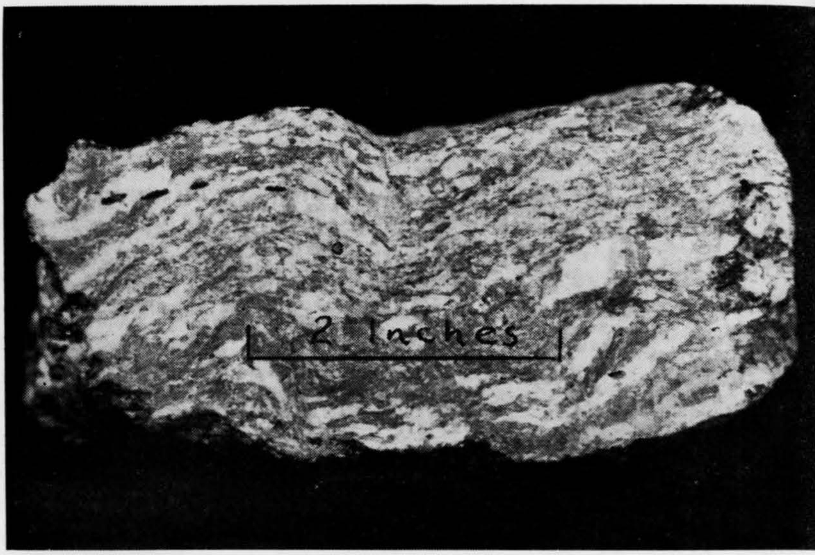

Fig. 12. Augen mica gneiss.

50 to 100 feet thick. Quartz-feldspar augen are locally well developed in the garnet-mica schist forming an augen gneiss (Figure 12) in the area south of Arabia Mountain.

Excellent exposures of saprolite and semi-fresh garnet-mica schist and muscovite quartzite occur along an east-west trending ridge, north of Rock Chapel Mountain. Augen mica gneiss crops out along Stephenson Creek, 1200 yards south of Arabia Lake dam. Thin layers of amphibolite are tightly infolded with the augen gneiss at this locality.

Garnet-mica schist—Fresh garnet-mica schist is dark gray, and the weathered rock is brown to red. In the final stages of decay the rock changes to a dark red, micaceous saprolite. The schistosity surfaces are sometimes corrugated.

In thin section the schistosity consists of an alternation of muscovite-biotite and quartz-feldspar bands 1.0 mm thick. The bands are frequently folded into minute crenulations which are ruptured by small shear planes.

The microscopic texture of the schist is granoblastic. Quartz and oligoclase grains have irregular, polyhedral boundaries. Idiomorphic grains of olive-green tourmaline sometimes exhibit a snowball structure formed by a spiral orientation of inclusions in the centers of the grains. Garnet crystals are usually flattened parallel to the schistosity.

The rock is composed of almost equal amounts of biotite, muscovite, oligoclase, and quartz, with accessory amounts of garnet, sillimanite, kyanite, epidote, and tourmaline. Staurolite, zircon, magnetite, and ilmenite are rare.

Quartz is generally flattened and shows undulatory extinction in thin section. Oligoclase ranges in composition from An_{23}-An_{28}. Biotite is pleochroic from X = light yellow < Y and Z = greenish brown. The indices of refraction of two samples from widely separated areas are $N\alpha$ = 1.593 (± .002) and $N\gamma$ = 1.650 (± .002). The composition (Winchell, 1951, Figure 257) is approximately 45% annite, 45% phlogopite, 5% siderophyllite, and 5% eastonite. Muscovite is slightly pleochroic from colorless to light yellow. $N\beta$ = 1.594 (± .002), $N\gamma$ = 1.600 (± .002). (—)2V = 40° (± 2°). The composition (Winchell, 1951, Figure 254) is approximately 50% muscovite, 37% picrophengite, and 13% ferrimuscovite. Small, deformed, pink to violet garnets have an index of refraction of 1.80-1.81 (± .005) and a range in specific gravity from 3.951-4.100.

Muscovite quartzite—Fresh specimens of quartzite are hard, compact and gray to brownish in color. The quartzite weathers to a light brown, friable rock.

The rock is fine- to medium-grained and well foliated because of a subparallel orientation of muscovite flakes between and within quartz grains. A faint banding is sometimes present in the form of color changes or changes in grain size.

The microscopic texture in xenoblastic and quartz grain boundaries are sutured. Quartz shows pronounced undulatory extinction and fracturing.

Biotite Gneiss

Medium-grained biotite gneiss is a light gray, well-banded rock which is generally found as a soft reddish saprolite except in the beds of small streams. It is similar in appearance to the Lithonia gneiss, but it is distinguished from the Lithonia gneiss by the lack of shear zones and flow folds.

The gneiss is fine- to medium-grained (0.5 mm to 2.0 mm), gray-white, and evenly banded. The banding is formed by an alternation of biotite-rich and quartz-feldspar bands. Quartz is frequently flattened and stretched parallel to streaking of biotite flakes, forming a pronounced lineation.

Thin sections of the gneiss show a marked parallelism of biotite flakes and flattening of quartz parallel to the biotite. The texture is xenoblastic and slightly inequigranular. The grains of the groundmass range in diameter from 0.1 mm to 1.0 mm, and large quartz and oligoclase grains are up to 3.0 mm in diameter.

The biotite gneiss is composed of quartz, oligoclase and biotite, with small amounts of microcline, secondary muscovite, epidote, magnetite, and zircon. Stream-panned saprolite produces a rather large residue of magnetite and ilmenite (black sand) with a small amount of zircon.

Muscovite-Quartz Schist

Muscovite-quartz schist forms a small ridge in the area southwest of Centerville which can be traced for a distance of nearly five miles. The contacts of the formation were located on the basis of float pebbles except in stream and road exposures where the contact was actually seen.

The schist is a fine- to medium-grained rock composed almost entirely of quartz and muscovite. It is nearly white in fresh specimens but changes to a light tan when weathered. The schist contains feldspar porphyroblasts in outcrops located in a small stream 2000 yards S30°W of Centerville.

Amphibolite

General statement—The amphibolites of the district are divided into three lithologic types on a mineralogical basis: pyroxene-hornblende gneiss, epidote-hornblende gneiss, and talc-actinolite-chlorite augen schist. Pyroxene-hornblende gneiss and epidote-hornblende gneiss are treated together as hornblende gneiss because they are similar in color, texture, composition and occurrence. They differ only in their areal distribution and in the substitution of pyroxene for epidote. Both of these latter features are dependent upon metamorphism (see section on metamorphism).

Hornblende gneiss—Pyroxene-hornblende gneiss occurs as bands within garnet-mica schist and porphyroblastic biotite gneiss in a zone approximately one-half mile wide bordering the Lithonia gneiss. Past this zone, or metamorphic aureole, epidote-hornblende gneiss takes the place of the pyroxene-hornblende gneiss.

Fresh specimens of dark green pyroxene- and epidote-hornblende gneiss are extremely hard. Both rock types contain a pronounced megascopic banding, ranging from less than 0.5 mm to 10.0 mm thick. The banding is formed by a concentration of dark- and light-colored minerals into alternating layers. The rock is usually fine-grained, but the grain size ranges from fine (0.1 mm) to coarse (20.0 mm).

With a hand lens, light green epidote or pyroxene grains can be seen scattered between the hornblende and plagioclase grains. The hornblende is either matted at random on the banding surfaces or oriented parallel to minor crenulations.

Pyroxene- and epidote-hornblende gneiss show a crystalloblastic texture in thin section. Porphyroblasts of hornblende (0.1 mm to 1.0 mm) are contained in a fine grained groundmass of plagioclase and epidote or pyroxene. Plagioclase grains are polyhedral, and have irregular boundaries. Rare porphyroblasts of garnet are idioblastic.

Hornblende grains in several thin sections contain numerous, small globular inclusions of quartz and plagioclase. A slight amount of chloritization of hornblende was noted in one thin section, and small remnants of hornblende were found within epidote clusters in most sections of epidote-hornblende gneiss.

A distinguishing feature in many thin sections is the abundance of slightly rounded sphene grains included in hornblende and andesine (Figure 13).

The mineral paragenesis of the hornblende gneisses determined from grain boundary relationships is sphene→hornblende→andesine→epidote and/or diopside. However, in one specimen (sample A-76) hornblende appears to have been the last mineral formed because it contains inclusions of quartz, andesine and epidote.

The chemical compositions of the several types of horn-

Fig. 13. Slightly rounded sphene grains in amphibolite. Polarized light. X40.

blende gneiss other than biotite-hornblende gneiss are approximately the same (Table 2, nos. C79, C-1486, and C1060).

The mineralogical compositions of two samples of hornblende gneiss are given in Table 3.

The plagioclase of epidote-hornblende gneiss ranges from An_{27}-An_{39} and that of the pyroxene-hornblende gneiss ranges from An_{38}-An_{43}.

Two types of hornblende are found in different samples of epidote-hornblende gneiss. A more abundant type is biaxial negative with a 2V of 74°. $Z \wedge C = 16°$-18°. $N\beta =$ 1.660-1.666 (± .002) and $N\tau = 1.666$-1.674 (± .002). The other type has a (—) 2V ranging from 59° to 62°. $Z \wedge C =$ 15°-19°. $N\beta = 1.662$-1.670 (± .002) and $N\tau = 1.668$-1.674 (± .002). Both varieties are pleochroic from X = yellowish green <Y = dark green> Z = blue-green.

The hornbledge of the pyroxene-hornblende gneiss is pleochroic from X = yellowish green <Y = dark green> Z = blue-green. It has a biaxial negative 2V ranging from 68°-72°. $Z \wedge C = 15°$. $N\beta = 1.666$-1.672 (± .002) and $N\tau =$ 1.672-1.677 (± .002).

The optical properties of two hornblendes are compared with those of hornblendes from Winchell (1945, Table 3) in Table 4.

On the basis of the above optical data, these hornblendes apparently fall in group 3 of Sundius (1946, Figures 8 and

10). The indices of refraction are too high for the actinolites (group 1) and the 2V's are too low for the bulk of the analyses of group 2 (common hornblendes).

TABLE 2

Chemical Analyses* of Hornblende Gneisses

	C839	C79	C1486	C1060
SiO_2	63.64	45.83	44.79	45.71
Al_2O_3	20.03	20.04	22.61	22.14
Na_2O	0.86	1.14	1.19	1.39
K_2O	0.40	0.17	0.29	0.56
CaO	6.88	13.75	11.95	13.25
Fe_2O_3	6.22	12.76	14.39	12.71
FeO	trace	trace	0.00	trace
MgO	2.17	3.17	3.82	2.76
TiO_2	0.00	1.20	0.60	1.30
SO_3	trace	1.82	0.00	0.00
P_2O_5	0.00	0.03	0.02	0.14
Ignition	0.00	0.25	0.35	0.00
Totals	100.20	100.16	100.01	99.96

*Analyses performed in the laboratory of the Georgia Dept. of Mines by L. H. Turner, chief chemist, 1951.

C839—Biotite-hornblende gneiss from the bed of a small tributary of Stone Mountain Creek, 1300 yards N25°E of Bermuda.

C79—Epidote-hornblende gneiss from a small hill, 1500 yards N67°E of Centerville.

C1486—Hornblende gneiss from a locality 1900 yards S75°W of Bermuda, on the south side of a small stream.

C1060—Pyroxene-hornblende gneiss from the west bank of a small tributary of Pole Bridge Creek, 2200 yards N85°W of the Lithonia Post Office.

TABLE 3

Modal Analyses of Pyroxene-Hornblende Gneiss and Epidote-Hornblende Gneiss in Weight Percent

	Sample No. (1)	(2)
Plagioclase	28.3 (An_{43})	5.9 (An_{27})
Hornblende	30.8	64.4
Diopside	30.8	------
Epidote	trace	29.0
Sphene	9.6	0.6
Ores	trace	trace
Quartz	------	------
Tourmaline	trace	------
Total	99.5%	99.9%

(1)—Pyroxene-hornblende gneiss from a road cut, 2500 yards N48°W of Lithonia Post Office.

(2)—Epidote-hornblende gneiss from a locality 3000 yards S17°W of Redan.

The hornblendes of the epidote amphibolites have an Mg:Fe″ + Fe″′ + Mn + Ti ratio of 65:35 and those of the pyroxene amphibolites have a ratio of 60:40 (approximately). Both varieties are high in aluminum (Sundius, 1946, Plate 8, curve 3).

TABLE 4

Optical Properties of Hornblendes

Sample		2V	Z∧C	Nβ	Nγ
L193	(—)	70°	15°	1.666	1.672
88	”	70°	15°	1.664	1.672
A76	”	75°	18°	1.660	1.666
41	”	75°	19°	1.662	1.670

L193—Hornblende from pyroxene-hornblende gneiss from a road cut 2500 yards N48°W of Lithonia Post Office.

88—Hornblende from a coarse appinite (Hallimond, 1943, Table 1, no. 135; see also Winchell, 1945, Table 3, no. 88).

A76—Hornblende from epidote-hornblende gneiss in a road cut 4300 yards N88°W of Lithonia.

41—Hornblende from a hornblendite xenolith (Hallimond, 1943, Table 1, no. 62; see also Winchell, 1945, Table 3, no. 41).

Epidote is colorless to pale brown and is slightly pleochroic. It has a biaxial negative 2V of 80° (±). $N\beta = 1.730\text{-}1.735$ (± .005). The composition (Winchell, 1951, Figure 343) is approximately 85% $HCa_2Al_3Si_3O_{13}$ and 15% $HCa_2Fe_3Si_3O_{13}$.

Pyroxene is colorless to slightly green and is faintly pleochroic. It has a biaxial positive 2V = 59°. $Z \wedge C = 42°$. $N\beta = 1.694$ (± .002) and $N\gamma = 1.710^{+}$. The composition (Hess, 1949, Plate VI) is approximately 65% diopside, 35% hedenbergite.

Talc-actinolite-chlorite schist—Talc-actinolite-chlorite schist occurs as small lenticularly shaped bodies within several hornblende gneiss layers. The schist is light green and contains numerous talc-actinolite augen up to one inch long embedded in a chlorite groundmass. These augen form knots on the weathered surface (Figure 14), and chlorite flakes produce a poorly developed schistosity around them.

Fig. 14. Talc-actinolite-chlorite schist showing the development of "knots" (augen) on the weathered surface. One mile N40°E of Bermuda.

Talc is colorless in thin section. It has a small biaxial negative 2V and has a length-slow orientation. $N\alpha = 1.536$, $N\beta = 1.586$, and $N\gamma = 1.588$. Talc with almost the same optical properties (Larsen and Berman, 1934, p. 164) has a composition $3MgO.4SiO_2.H_2O$.

Actinolite is slightly pleochroic from colorless to light green. Elongate grains are length slow. The optical constants are: (—) $2V = 84°$; $Z \wedge C = 19°$; $N\beta = 1.628$ ($\pm$ .002) and $N\gamma = 1.637$ ($\pm$ .002). These data indicate an iron-poor actinolite with a composition (Winchell, 1951, Figure 323) of:

90% $H_2Ca_2Mg_5Si_8O_{24}$
10% $H_2Ca_2Fe_5Si_8O_{24}$

The chlorite has a biaxial positive $2V = 12°$. $N\beta = 1.581$ ($\pm$ .002). Polysynthetic twinning is common. It is slightly pleochroic from X and Y = pale green > Z = colorless.

Biotite-Hornblende Gneiss

Medium-grained, evenly banded biotite-hornblende gneiss crops out in the bed of a small tributary of Stone Mountain Creek, 1300 yards N25° E of Bermuda. Seventeen hundred yards N40°W of Bermuda, the gneiss grades into amphibolite.

The gneiss has a pronounced megascopic banding composed of alternating concentration of light and dark colored constituents. Small, greenish epidote or pyroxene grains fill the interstices between biotite and hornblende grains. Locally, thin bands of amphibolite and biotite gneiss are interlayered within the biotite-hornblende gneiss.

In thin section the edges of the hornblende grains appear frayed and highly embayed by biotite and epidote.

The gneiss is composed of variable amounts of andesine, biotite, hornblende, quartz and epidote. Pyroxene is locally present in place of epidote, and hornblende is locally absent. The rock has the chemical composition of a diorite (see Table 2, C839).

The plagioclase is sodic anadesine with a composition of An_{27}-An_{36}. Hornblende is pleochroic from X = greenish yellow < Y = dark green > Z = blue-green. It has a biaxial negative 2V = 65°. Z $\wedge$ C = 11°. N_β = 1.666 (± .002) and N_γ = 1.674 (± .002). Epidote and pyroxene have the same optical properties as those described under the amphibolites.

Porphyroblastic Biotite Gneiss

The most abundant metamorphic rock type in the map area is a medium- to coarse-grained biotite gneiss which contains andesine porphyroblasts along the banding planes. The porphyroblasts attain a size of 10.0 mm in diameter and are largest in gneiss near the contact with Stone Mountain granite.

Thin, non-mappable layers and lenses of amphibolite and other minor rock types are frequently interlayered in the gneiss (see minor rock types below).

Saprolite exposures are found in many road cuts, but fresh exposures are rare except along small streams. Excellent exposures of interlayered porphyroblastic biotite gneiss, fine-grained biotite gneiss, and amphibolite crop out along Crooked Creek, 3000 yards south of the crest of Stone Mountain.

Hand specimens show an abundance of irregular to lens-shaped andesine porphyroblasts which range from 1.0 to 10.0 mm in diameter. Light green epidote grains are commonly associated with the porphyroblasts.

In thin section, subparallel biotite flakes are concentrated in bands which wrap around the andesine and quartz grains. Quartz grains are usually flattened parallel to the banding. The texture is porphyroblastic. Albite twinning planes in the porphyroblasts are sometimes bent, showing that deformation took place during or slightly after growth. An example of an andesine porphyroblast is shown in Figure 15.

The gneiss is composed of quartz, andesine and biotite, with accessory epidote, zircon, magnetite, and ilmenite. The andesine has a composition of An_{27}-An_{34}. Biotite is pleochroic from X = greenish yellow $<$Y and Z = dark green. $N_\alpha >$ = 1.586-1.588 (± .002) and N_γ = 1.636-1.638 (± .002). Its composition (Winchell, 1951, Fig. 257) is 38% annite, 38% phlogopite, 12% siderophyllite, and 12% eastonite.

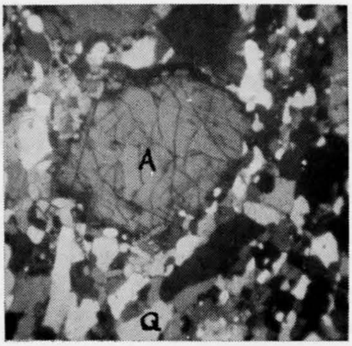

Fig. 15. Small andesine porphyroblast in porphyroblastic biotite gneiss. Crossed nicols. X40.

Minor Rock Types

Fine-grained biotite gneiss is interlayered with hornblende gneiss along a small stream 2000 yards S30°W of Centerville.

Sillimanite-quartz schist and **garnet-cummingtonite gneiss** are interlayered with amphibolite and garnetiferous biotite gneiss along an abandoned county road, 2000 yards N25°W of Norris Lake dam. Sillimanite needles, imbedded in quartz grains, and kyanite porphyroblasts are associated with one another in the sillimanite-quartz schist. Cummingtonite forms lath-shaped grains aproximately 10.0 mm long matted on the banding surfaces of garnet-cummingtonite gneiss. The cummingtonite is colorless to light green and faintly pleochroic in thin section. $(+)2V = 76°$, $Z \wedge C = 18°$. It is length slow and it is commonly twinned parallel to $\{100\}$.

Muscovite-kyanite schist forms a sandy, micaceous saprolite in a road cut located 1200 yards N20°W of the Norris Lake dam. The schist is interlayered concordantly with biotite gneiss and amphibolite. The banding and schistosity strike N70°W and dip 25°N.

Biotite-muscovite augen schist crops out along Yellow River, 4500 yards N67°W of Centerville. The rock contains feldspar augen up to 10.0 mm long which tail into a granular mass of quartz and feldspar grains. Some of the augen contain small, undeformed garnet crystals, but larger garnet porphyroblasts within the schist are flattened.

Garnet-kyanite gneiss is altered to semi-saprolite in a small road cut, 400 yards S20°W of the intersection of longitude 84° 05′ west and latitude 33° 50′ north. The rock contains garnet porphyroblasts which range from 1.0 mm to 2.0 mm in diameter and contains kyanite blades up to 5.0 mm long. The kyanite is oriented parallel to a biotite lineation which strikes N60°W and plunges 5°NW. The kyanite blades are slightly bent but not fractured. Feldspar grains have largely altered to clay.

Phlogopite quartzite was found interlayered with biotite gneiss and amphibolite in a small stream, 2400 yards S32°W of Centerville. The rock is composed of quartz, phlogopite, muscovite and accessory pyrite. The phlogopite is light brown and is slightly pleochroic from light brown to yellowish brown. It is biaxial negative with a small 2V ($= 10° \pm$). The dispersion is $r < v$. $N\beta$ and $N_\gamma = 1.594$ ($\pm .002$).

IGNEOUS ROCKS

Stone Mountain Granite (Quartz-Monzonite)

General Statement—The Stone Mountain granite was studied as early as 1894 by Purington (1894) who classified the rock as granite on the basis of its megascopic appearance. Watson (1902) made a more detailed study of the rock and classified it as a biotite-bearing muscovite granite (p. 114).

Modal analyses of six samples of the rock (Table 5) show that the ratio of oligoclase to microcline is nearly 50:50. Four of the samples have slightly more oligoclase than microcline, and two of the samples have slightly more microcline than oligoclase. The average ratio of oligoclase to microcline is approximately 52:48.

A rock of the mineralogical composition of the Stone Mountain granite falls into the adamellite (quartz-monzonite) category of the classifications of Johannsen (1939, Table 37), Hatch, Wells and Wells (1949, pp. 190-196), and Lincoln (Johannsen, 1939, Table 36). Shand's classification (Johannsen, 1939, p. 135) would place the rock on the borderline between potash and soda granite.

In order to conform to the usage of most authors, the Stone Mountain rock is reclassified as quartz-monzonite. For simplicity, however, the name granite is retained in the sense of the term used by Hatch, Wells and Wells (1949, p. 190) who state, "When the term 'granite' is used without any qualifying adjective, it signifies a rock of the appropriate coarse texture, composed essentially of quartz, feldspar and mica".

Distribution—The stone Mountain granite pluton has a squid-shaped map pattern. The main body covers an area of approximately 10 square miles east and northeast of the village of Stone Mountain. Near Centerville, the granite forms a series of dikes trending N70°W. North of Redan it forms a series of northeasterly trending dikes. The latter are elliptical in plan, swelling in the center and pinching at the ends.

Megascopic character—The Stone Mountain granite is a fine- to medium-grained rock composed of quartz, feldspar, and muscovite with a minor amount of brown biotite. Biotite rich phases of the rock are located in the areas two and one-third miles N10°W of Lithonia and two miles N70°W of Arabia Lake.

Small tourmaline clusters are scattered throughout the granite in the vicinity of Stone Mountain (Fig. 37). They are composed of small, sub-parallel black tourmaline needles contained in a matrix of quartz and albite. The tourmaline radiates as in a sheaf of wheat. The white matrix grades imperceptibly into gray, micaceous granite.

Microscopic character—Thin sections cut perpendicular to the foliation show a slight alignment of mica flakes. The texture is allotriomorphic granular and faintly seriate. The groundmass, composed of quartz, oligoclase and microcline, ranges from 0.5 to 2.0 mm. Occasional phenocrysts of oligoclase and microcline attain a size of 3.0 mm. Muscovite occurs enclosed in, or at the boundary of quartz and feldspar grains. Oligoclase and microcline grains are poikilitic, containing numerous globular or irregular inclusions of quartz. Complex twinning is common in the oligoclase. Twin laws determined by the Rittmann method (Emmons, 1943, pp. 115-133) include acline-carlsbad, acline, carlsbad, albite-acline, and albite-ala B. Albite twins are uncommon.

The mineralogical composition is given in Table 5, numbers S59, S62, A208, S68, L58 and A68.

Oligoclase has a composition of An_{10}-An_{11}. Muscovite is slightly pleochroic from colorless to light yellow. The indices of refraction of the muscovite are $N\beta = 1.592$ ($\pm$ .002) and $N\gamma = 1.602$ ($\pm$ .002). (—)2V = 40° ($\pm$). The composition (Winchell, 1951, Figure 254) is 52% muscovite, 37% picrophengite, and 11% ferrimuscovite. Biotite is pleochroic from X= light yellow < Y and Z = dark brown. The indices of refraction are $N\alpha = 1.595\text{-}1.598$ ($\pm$ .002) and $N\gamma = 1.644\text{-}1.648$ ($\pm$ .002). The composition (Winchell, 1951, Figure 257) is 60% siderophyllite, 20% eastonite, 15% annite, and 5% phlogopite.

TABLE 5

Modes of the Stone Mountain Granite in Weight Percent

	Sample No.					
	S59	S62	A208	S68	L58	A68
Quartz	26.2%	37.1%	29.9%	27.2%	29.3	35.0
Oligoclase	35.2	27.0	29.7	39.3	28.2	27.0
Microcline	27.3	26.5	25.8	22.1	35.8	29.8
Muscovite	9.6	8.5	11.9	10.3	5.8	6.0
Biotite	1.7	0.9	2.0	1.1	.9	1.6
Epidote	X	X	0.5	X	X	.6
Garnet	X	X	------	------	X	------
Apatite	X	X	X	X	X	X
Zircon	X	X	X	------	X	X
Pyrite	------	X	------	------	------	------
Rutile	------	------	X	------	------	------
Sericite	X	X	X	X	X	X
Calcite	------	------	------	------	------	------
Totals	100.0	100.0	99.6	100.0	100.0	100.0
X Trace						

S59—Sample of Stone Mountain granite from a small quarry located 3000 yards S80°E of the crest of Stone Mountain.

S62—Sample of Stone Mountain granite from Flat Rock Quarry, located ½ mile north of Stone Mountain.

A208—Sample of Stone Mountain granite from the Venable Quarry, located on the SW side of Stone Mountain.

S68—Sample of Stone Mountain granite from the Kellogg Quarry, located on the east side of Stone Mountain.

L58—Sample of Stone Mountain granite from the Wells Quarry, located about one mile north of Redan.

A68—Sample of Stone Mountain granite from the Campbell property, located about ½ mile southeast of Centerville.

Uranophane, hyalite and damourite are found on joint surfaces of the Stone Mountain granite. Uranophane, a canary yellow oxide of uranium, has the following chemical composition (Watson, 1902, p. 115):

Ignition	13.28
SiO_2	18.55
$(UO_2)_2, Fe_2O_3P_2O_5$	4.95
Al_2O_3	6.33
CaO	6.64
MgO	1.98
$U(UO_4)_2$	47.18
Total	98.91

Panned samples of saprolite yield a very small residue of colorless to light brown prismatic zircon crystals, clinozoisite, and pyrite.

Pegmatite Dikes

Medium- to coarse-grained pegmatite dikes are intrusive in all rocks of the district except diabase dikes and alluvium.

Pegmatite dikes in the Lithonia gneiss are usually small and irregular in outline. They are commonly discordant with the banding but in some cases they are partially concordant (Plate 6, Figure 1).

Large dikes up to several hundred feet thick and 500 yards long are found in the metamorphic series, e. g., in the area two-thirds of a mile north northwest of Lithonia.

Long, narrow dikes several inches to several feet thick are found in abundance on the northwest side of Stone Mountain. The pegmatites are composed of small to large potash feldspar and muscovite phenocrysts contained in a finer groundmass of quartz, albite, potash feldspar, and biotite. Tourmaline is a frequent accessory which occurs as small to large black, striated crystals. Pink garnets are common, and violet fluorite is rare. Molybdenite is very rare.

Tourmaline crystals from a pegmatite on the southern slope of Arabia Mountain are pleochroic from light brown to black. The indices of refraction are: $N_e = 1.638$ ($\pm$ .002); $N_o = 1.670$ ($\pm$ .005). Tourmaline from a pegmatite on the south side of Stone Mountain is pleochroic from light brown to brown-green. The indices are: $N_e = 1.626$ ($\pm$ .002);

N_o = 1.654 (± .002). Molybdenite occurs as small, lead gray, foliated masses in several pegmatite dikes on Little Stone Mountain.

Aplite Dikes

Fine- to medium-grained aplite forms thin veins parallel to the banding, and fills shear zones in the Lithonia gneiss. At Rock Chapel Mountain it forms discordant dikes up to fifteen feet thick.

The aplite is composed of quartz, microcline, and albite (An_{10}) with occasional magnetite octahedra and little or no mica. Table 1, no. L23 (5) is a modal analysis of an aplite vein from Collinsville Mountain.

White aplite dikes and veins, numerous on the south side of Stone Mountain, commonly contain rosettes of tourmaline crystals up to two inches long. Some aplite studied by the writer forms composite dikes in which aplite occupies the center, and pegmatite forms one or both borders. Lester (written communication) states that in some dikes pegmatite occupies the center and aplite forms the borders.

Diabase Dikes

Fine-grained, dark green to black diabase forms large and small dikes in the metamorphic and igneous rocks of the northeast portion of the district (Plate 1). They trend from N25°-N40°W. The largest dike is almost four miles long and approximately fifty feet thick. The smallest observed was only a few inches thick and of unknown length.

The rock is very resistant to weathering. Consequently it forms small ridges whose summits are covered with large, rounded boulders ("nigger heads"). Surface weathering produces a deep orange-brown to yellow-brown clay.

According to Lester and Allen (1950, p. 1219), the rock is composed of plagioclase and pyroxene and smaller amounts of olivine, hornblende, magnetite, and pyrite. Secondary minerals include uralite, kaolinite, and iddingsite.

ALLUVIUM

Stream alluvium covers the beds, and produces wide terraces along the courses of the larger streams of the district.

In addition, a heavy colluvial cover, containing large, angular quartz blocks, is present over the bedrock in the area south of Stone Mountain.

STRUCTURAL GEOLOGY

STRUCTURES OF THE LITHONIA GNEISS

Banding

The banding of the Lithonia gneiss, although not deformed near the contact with the overlying mica schist, rapidly becomes flow folded (contorted) and sheared a short distance within the gneiss.

The contact between the Lithonia gneiss and mica schist is concordant and conformable 2100 yards N42°E of the Consolidated Quarry Corporation office (Rock Chapel Mountain). The banding and schistosity strike N70°W and dip 40°-45°N. Eight hundred yards north of Klondike, the contact is also concordant. The banding and schistosity strike N69°W and dip from 75°S to 75°N.

Very few contacts can be seen, but most can be inferred within a distance of about 50 feet.

Garnetiferous Layers

Individual garnetiferous layers are almost always oriented parallel to the banding of the biotite gneiss (Plate 6, Figure 2; Plate 5, Figures 2, 3, 4, 5, and 7), although in some instances they have been faulted and rotated out of conformity with the banding (Figure 20). Frequently the layers have been greatly attenuated (Figure 16).

Flow Folds

The banding of the Lithonia gneiss has been deformed into small folds which range from slight undulations to complex contortions, with variations from one extreme to the other often within a distance of a few yards (Pl. 6, Figs. 1 and 3). The folds range from several inches to several feet in half wave length and amplitude.

The flow fold axes vary considerably in orientation locally,

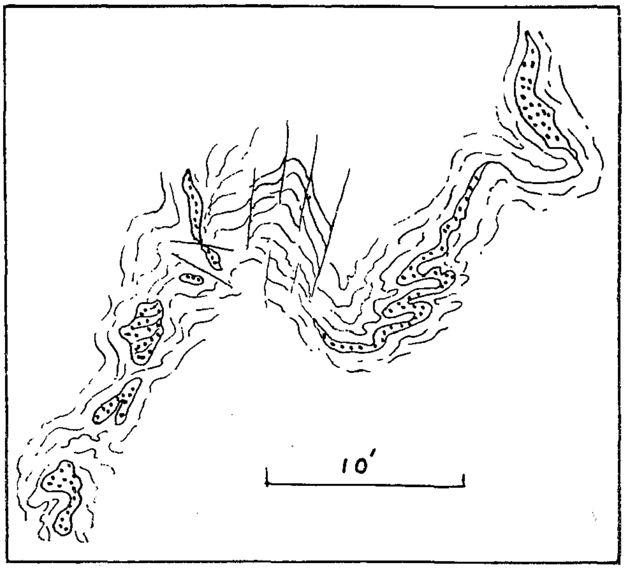

Fig. 16. Attenuated, faulted and rotated garnetiferous layers in the Lithonia gneiss. Located southwest of Arabia Mountain.

but in general they plunge gently in a northeasterly or southwesterly direction (Plate 3).

Ptygmatic Folds

Quartz veins in the Lithonia gneiss have been deformed into small, ptygmatic folds with thickened crests and attenuated limbs (Plate 5, Fig. 1). The veins are always concordant with the gneissic banding.

Several authors have described ptygmatic folds from other localities and have postulated various theories for their origin. Sederholm (1926, p. 73) stated that "the veins were probably all originally straight, filling fissures originated in the rock masses". He believed the folding phenomenon was more closely related to fluidal movements than to typical folding of solid rocks (1926, p. 80). Read (1931, p. 150) thought "the tortuous form of ptygmatic folds results from the resistance to plane fissuring of the country rock". Thus the folded form was the result of vein material filling irregular fissures. Kuenen (1938, pp. 11-27) believed the folding was due to compression of plastic veins embedded in more ductile country rock.

The shape of the ptygmatic veins in the Lithonia gneiss, viz., thickening of the crests and thinning of the limbs, indicates that the vein material was plastic during deformation. It seems likely that the folding took place in a manner similar to that postulated by Kuenen.

Shear Zones

Two sets of shear zones were formed in the Lithonia gneiss at a late stage in its deformation. Individual shear zones from one to ten feet long and up to two inches thick are filled with recrystallized gneiss or aplite or pegmatite dikes. Several examples are illustrated in Fig. 20 and Plate 5, Figures 6 and 7.

Balk (1931, p. 361) described shear zones in the Adirondack anorthosite which are "filled with quartz, microcline

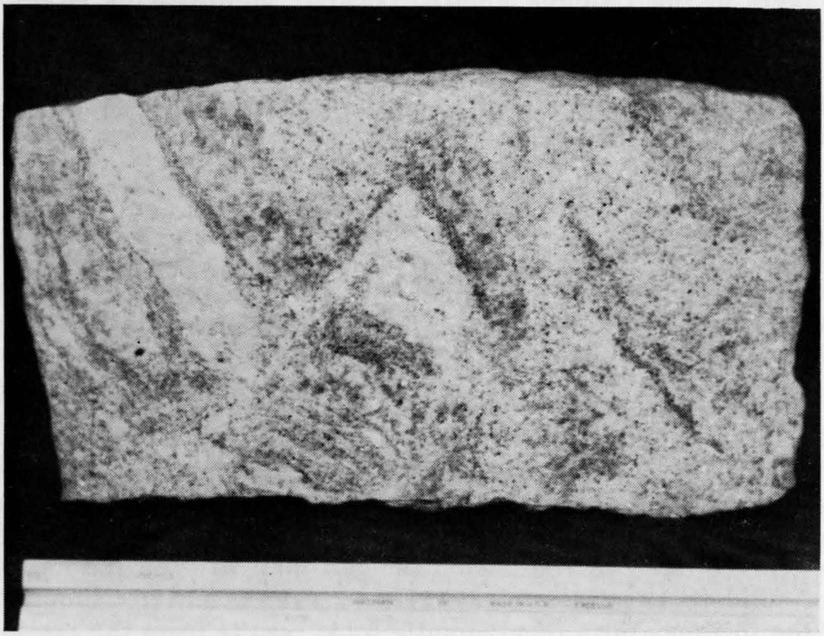

Fig. 17. Shear zone in building block of the Lithonia gneiss. Displacement of banding and aplite vein approximately four inches.

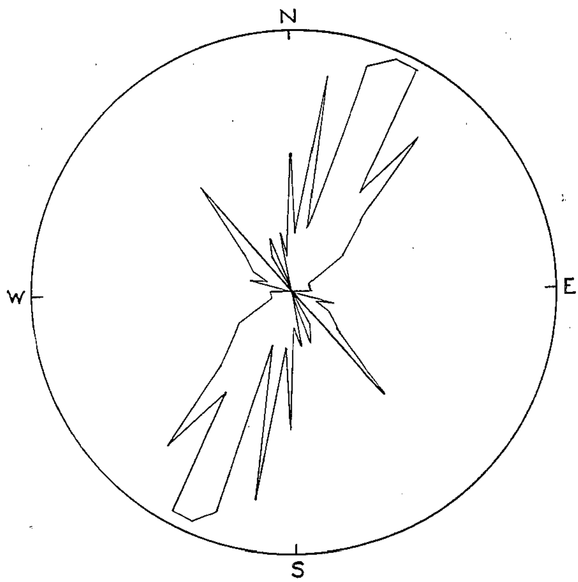

Fig. 18. Compass rose diagram of the strike of one hundred and twenty-two shear zones in the Lithonia gneiss.

and variable proportions of an acid plagioclase, garnet, epidote or chlorite". Cloos (1936, pp. 387 and 388) found flexures or shear zones in the contact zones of the Sierra Nevada pluton. Kvale (1948) described similar shear zones from the Bergsdalen Quadrangle, Norway.

The shear zones flex the banding. Displacement is usually negligible, although displacements of four inches are common (Fig. 17). More competent garnet-rich layers are often sharply faulted by the shearing (Figure 5).

One hundred and twenty-two shear zones were measured in the Lithonia gneiss, mostly in the area between Arabia Mountain and Rock Chapel Mountain. In most instances only the strike of the shear zones was measured since the dip could not be obtained from horizontal pavement surfaces. The strike of the zones has been plotted in Figure 18. A pronounced set strikes N25°E, and a less pronounced one strikes N40°W.

The two sets of shear zones are separated by an angle of 65° (± 5°).

In laboratory experiments* two similar sets of shear planes were formed in moist pottery clay subjected either to rotational or non-rotational stress. The shear planes formed during the initial stage of deformation include an angle of 62° (± 3°); continued stress widens the angle of separation of the shear planes to 70° (± 5°).

Rotational deformation produces a non-symmetrical rotation of the shear planes. The two sets of initial shear planes which form are separated by an angle of 62° (±). A synthetic set is oriented 10° (±) clockwise from the major component of stress and an antithetic set is oriented 72° (±) clockwise from the major component of stress. These two sets of shears are rotated during continued deformation to position 13° (±) and 80° (±), respectively, from the major component of stress. The antithetic shear planes are much more abundant than the synthetic shear planes.

The correlation of laboratory results with field data can only be approximated. However, the shear planes produced in the laboratory by rotational deformation are very similar in plan to the shear zones observed in the Lithonia gneiss.

Mica Lineation

Biotite and muscovite flakes in the banding surfaces of the Lithonia gneiss are stretched and crenulated. The long axes of the stretched micas and the axes of crenulations form lineations with a northwesterly strike. Seventy-five mica lineations have a maximum strike of N51°W and plunge 10°NW as shown in Figure 19. The Mica lineation was also observed in several pegmatite and granite dikes. The direction of lineation was not deflected by the shear zones.

The occurrence of the lineation in all phases of the Lithonia gneiss indicates that it was formed at a very late stage of deformation.

A second type of lineation, consisting of biotite-muscovite clusters aligned in the direction N20°E, are found in the Lithonia gneiss north of Centerville.

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*Structural experiments performed on moist pottery clay by Professor Ernst Cloos, Structural Geology Laboratory, The Johns Hopkins University, Baltimore, Md.

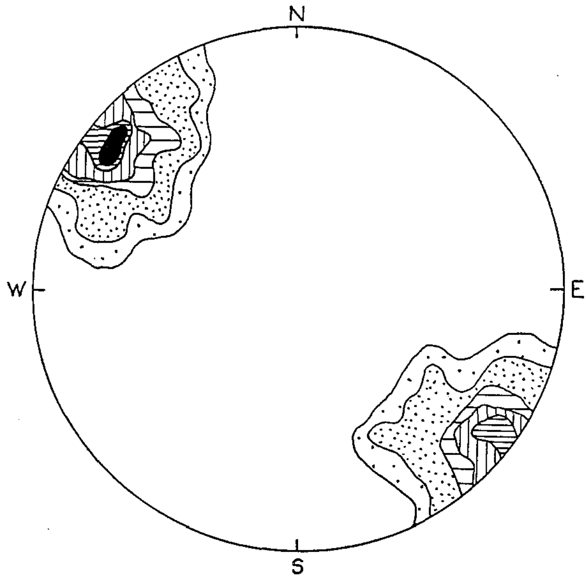


Fig. 19. Strike and plunge of seventy-five mica lineations plotted in the lower hemisphere of an equal area projection. Contours 1-3-5-10-20-22%.

Joints

Joints are not common in the Lithonia gneiss. Two sets are found in the area north of Rock Chapel Mountain. A pronounced set strikes N-S and dips vertically, and a less pronounced set strikes E-W and dips vertically. The former set is parallel to the grain of the gneiss, and the latter is parallel to the hardway of the gneiss.

On the south side of Little Stone Mountain one set of joints strikes northwesterly, and the other joints are randomly oriented. Some of the joint planes have been opened widely by movement of jointed blocks down the dip of the sheeting surfaces.

All pavements of the gneiss are sheeted parallel to the surface, forming layers from one to ten or more feet thick. The layers are thinnest near the surface and become progressively thicker at lower levels. The sheeting planes are utilized in quarrying operations.

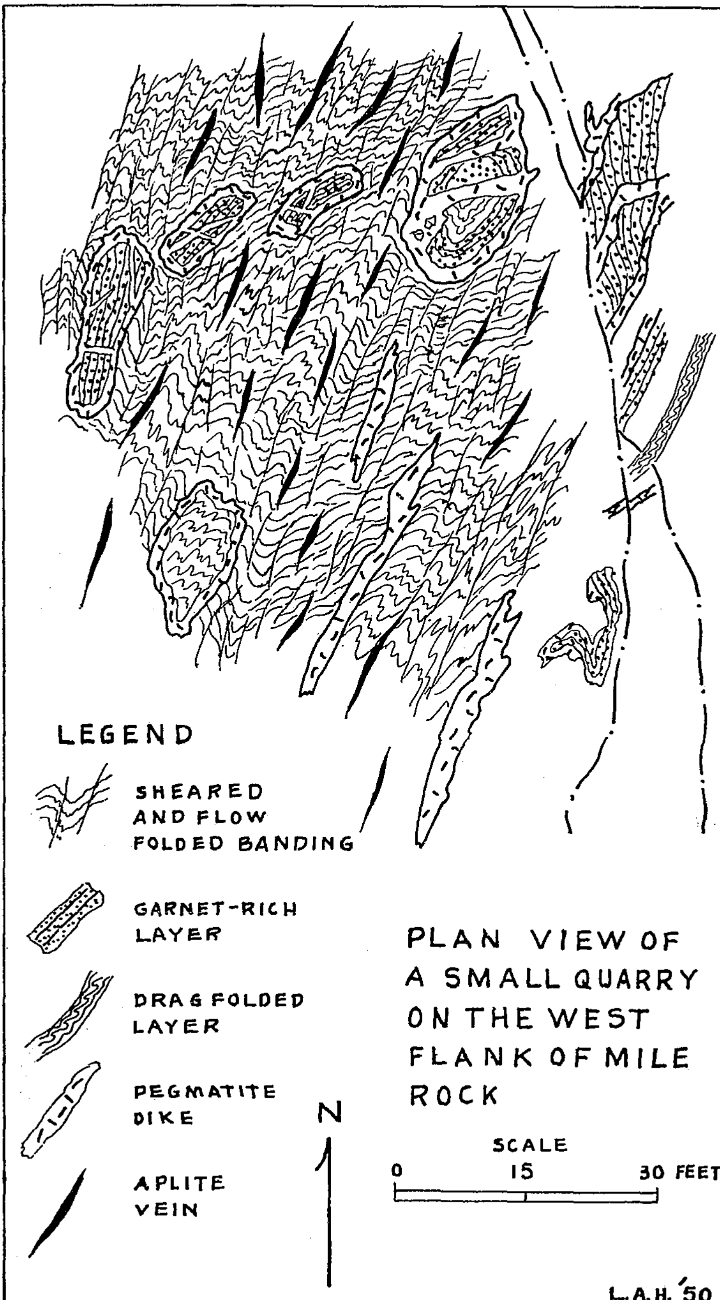

LEGEND
SHEARED AND FLOW FOLDED BANDING
GARNET-RICH LAYER
DRAG FOLDED LAYER
PEGMATITE DIKE
APLITE VEIN
N
PLAN VIEW OF A SMALL QUARRY ON THE WEST FLANK OF MILE ROCK
SCALE
0
15
30 FEET
L.A.H. '50

Fig. 20

Structures of Selected Exposures of the Lithonia Gneiss

A small quarry (Fig. 20) located on Mile Rock shows the typical structures of the Lithonia gneiss in that area. A pink garnetiferous layer has been faulted and rotated by a northwesterly trending set of faults. Swarms of aplite and pegmatite dikes were intruded along a very pronounced set of shear zones.

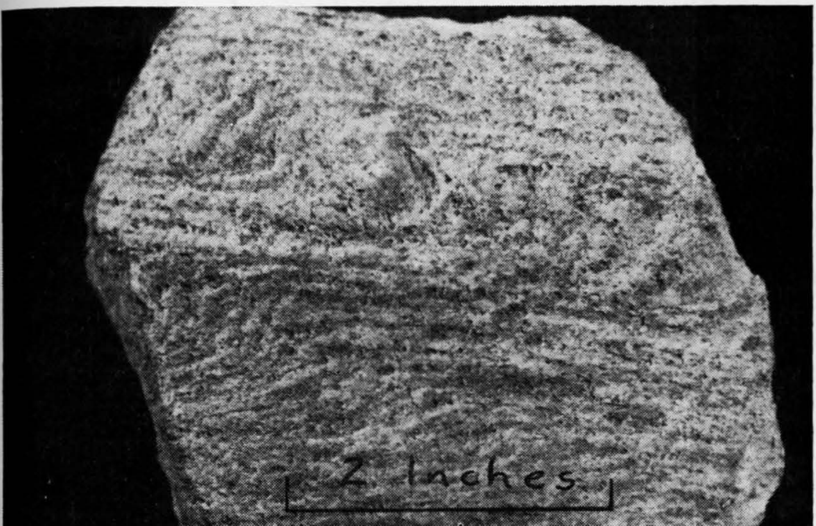


Fig. 21. Close up of drag-folded layer in the Lithonia gneiss.

A band of gneiss about two feet wide shows drag folds similar to those found in incompetent beds of folded sedimentary rocks. Figure 21 is a close up of the drag folds.

Detailed structures of the gneiss at Little Stone Mountain (Plate 4) are illustrated in Plate 5, Figures 1-8.

A pace and compass map of the DeKalb County Quarry, one-half mile north of Little Stone Mountain, is shown in Figure 22. Representative structures are shown in Plate 6, Figures 1-3.

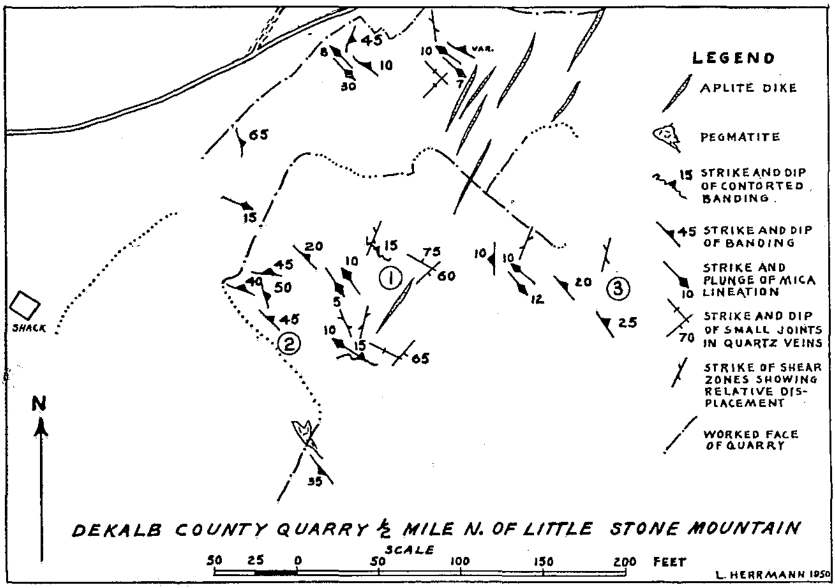

LEGEND
APLITE DIKE
PEGMATITE
STRIKE AND DIP OF CONTORTED BANDING
STRIKE AND DIP OF BANDING
STRIKE AND PLUNGE OF MICA LINEATION
STRIKE AND DIP OF SMALL JOINTS IN QUARTZ VEINS
STRIKE OF SHEAR ZONES SHOWING RELATIVE DISPLACEMENT
WORKED FACE OF QUARRY
SHACK
N
DEKALB COUNTY QUARRY ½ MILE N. OF LITTLE STONE MOUNTAIN
SCALE
50 25 0 50 100 150 200 FEET
L. HERRMANN 1950

Fig. 22

STRUCTURES OF THE METAMORPHIC ROCKS

Schistosity

The garnet-mica schist contains a pronounced schistosity formed by an alternation of biotite-muscovite and quartz-feldspar constituents in thin bands about 1 mm thick. The schistosity is commonly crenulated into minute folds several millimeters in amplitude and is occasionally ruptured by small fracture cleavage planes. The mica flakes bend around flattened garnet crystals in the schistosity planes.

The muscovite-quartz schist also has a very strong schistosity consisting of parallel orientation of muscovite flakes in a quartz matrix. In some localities the schistosity is badly deformed into small, tight, zig-zag folds several inches across.

Foliation

The muscovite quartzite contains a foliation rather than a schistosity or banding. The foliation consists of a parallel orientation of muscovite flakes within and between quartz grains. In some localities a faint color banding can be seen parallel to the foliation, but it is not easily recognizable.

Banding

The various types of gneisses of the area are weakly to strongly banded. A pronounced banding in the medium-grained biotite gneiss is formed by alternation of thin (2mm) biotite-rich and thicker (4mm) quartz-feldspar bands. The banding of the biotite-hornblende gneiss is formed by alternation of biotite-hornblende and quartz-feldspar bands.

Banding in the amphibolites ranges from thin laminations resembling the cleavage of slate to thicker color banding formed by alternation of epidote- or pyroxene-rich layers with hornblende-rich or plagioclase-rich layers. Frequently the banding is folded into small crenulations (Fig. 28).

The porphyroblastic biotite gneiss is thinly banded, but the banding is accentuated by the presence of small (1mm) to large (1 cm) porphyroblasts of plagioclase. A large exposure of saprolite and semi-saprolite porphyroblastic biotite gneiss, located along Georgia Route 141 approximately one mile north of Stone Mountain, illustrates this structure.

PLATE 5

Detailed Structures of the Lithonia Gneiss in the Vicinity of Little Stone Mountain

(Figures refer to inset numbers 1-8 of plate 4)

Fig. 1. Thin ptygmatically folded quartz vein (white) in the Lithonia gneiss.

Fig. 2. Concordant and conformable garnetiferous layer within the Lithonia gneiss. Discordant pegmatite dike has been intruded along a fault which offset the garnetiferous layer about 5 feet.

Fig. 3. Garnetiferous layer intruded by a pegmatite dike as in Fig. 2. Dike contains small inclusions of the garnetiferous layer.

Fig. 4. Concordant aplite veins (white) within the Lithonia gneiss, sheared and offset along gently dipping shear zones. Small pegmatite dike intruded the gneiss, deflecting the banding.

Fig. 5. Large layer of garnetiferous gneiss faulted and offset along sharp breaks. The biotite gneiss shows no effect of the faulting except for flowage around the more competent blocks. See also Fig. 5 (photograph in text).

Fig. 6. Biotite gneiss containing concordant aplite vein (white) sheared in horst and graben nature along small shear zones.

Fig. 7. Intensely sheared biotite gneiss.

Fig 8. Interlayered biotite gneiss and garnetiferous layers faulted and intruded by biotite gneiss.

PLATE 5

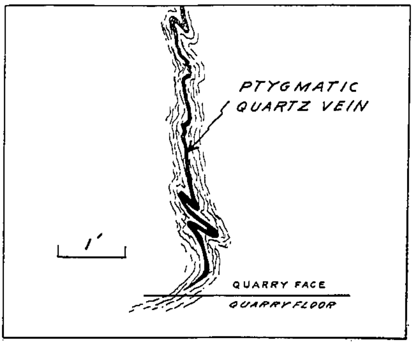


FIG. 1

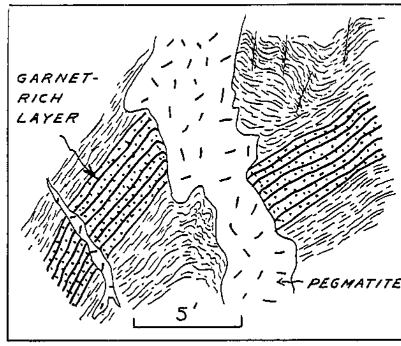


FIG. 2

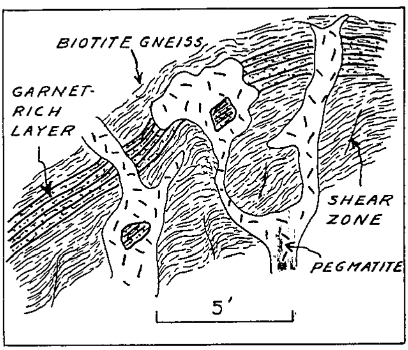


FIG. 3

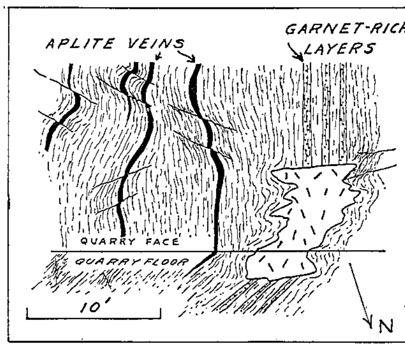


FIG. 4

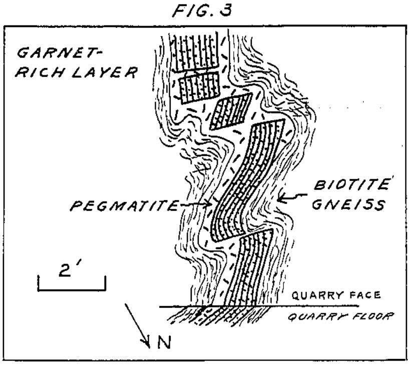


FIG. 5

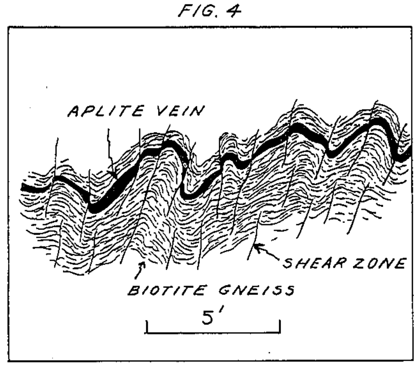


FIG. 6

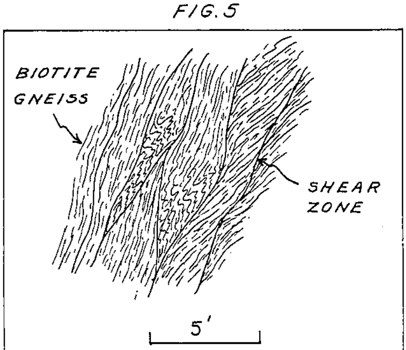


FIG. 7

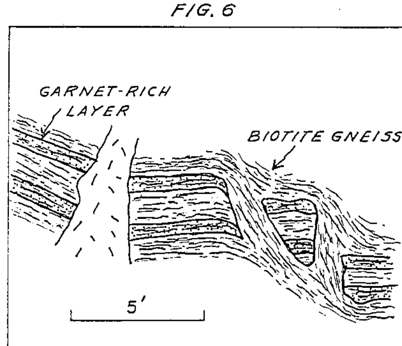


FIG. 8

PLATE 6

Detailed Structures in the Lithonia Gneiss at the DeKalb County Quarry

(Figures refer to inset numbers 1 to 3 of text Fig. 22)

Fig. 1. Sheared and flow folded biotite gneiss intruded by a late tectonic, partially discordant dike of pegmatite. Note that the pegmatite is slightly offset by a shear.

Fig. 2. Conformably interlayered biotite gneiss and garnet-rich layers which are flow folded and intruded by late tectonic pegmatite dikes.

Fig. 3. Evenly banded and slightly deformed biotite gneiss containing concordant quartz bands. Banding is cut and slightly offset by shears along which late tectonic aplite veins have been intruduced.

PLATE 6

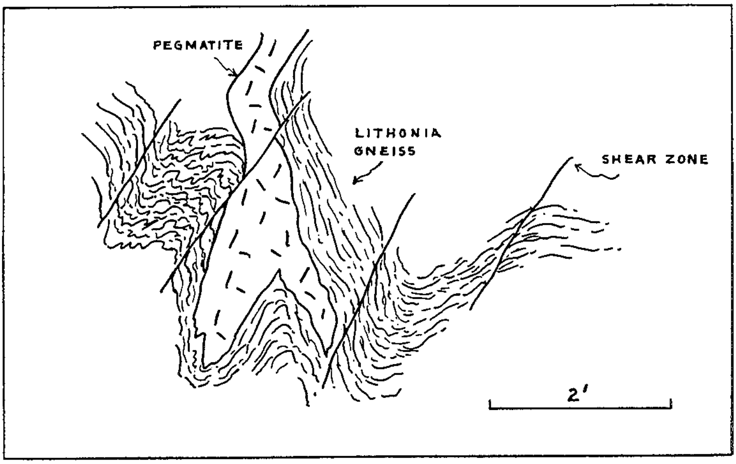


Fig. 1

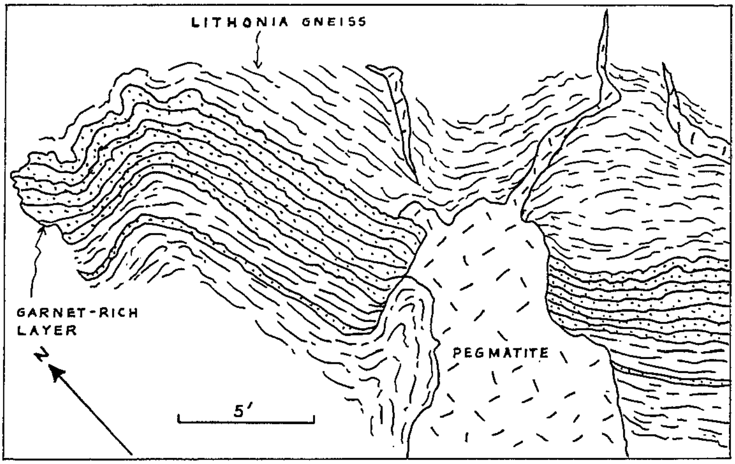


Fig. 2

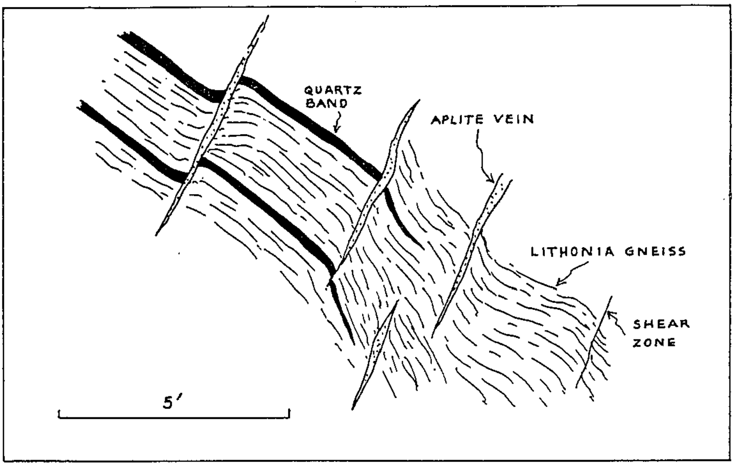


Fig. 3

Compositional Layering

The gneisses and schists of the metamorphic series form interstratified layers varying from a few feet to hundreds of feet thick. Fifteen hundred yards N28°W of Norris Lake dam, biotite gneiss, biotite schist and amphibolite are interlayered in a saprolite exposure (Fig. 23) in which an amphibolite layer is sheared into two augen-shaped lenses about six feet long. Numerous pegmatite dikes are almost parallel to the layering of the gneiss.

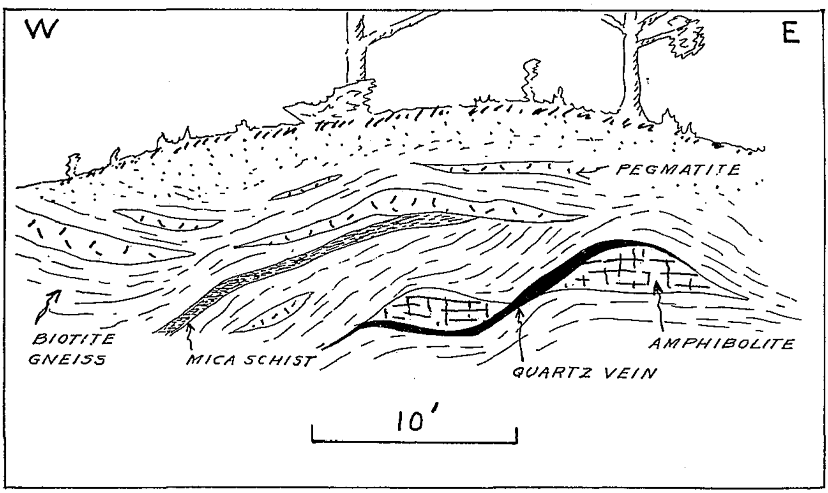


Fig. 23. Interlayering of gneiss, schist and amphibolite in saprolite exposure.

Three thousand five hundred yards N50°W of Norris Lake dam, a saprolite exposure of biotite gneiss in a road cut contains thin, concordant layers of amphibolite and mica schist (Fig. 24). Numerous other exposures showing the compositional layering of the gneisses can be seen throughout the area.

Minor Folds

Small open to isoclinal folds ranging in amplitude from several inches to several feet are found in the muscovite quartzite, amphibolite, muscovite-quartz schist, and gneisses.

Small folds up to several feet across are found throughout the length of the muscovite quartzite ridge. Near Norris Lake

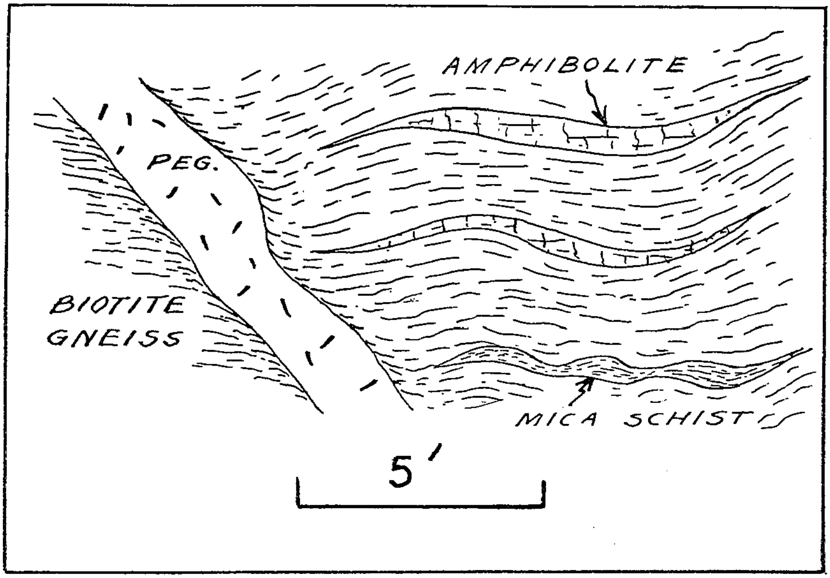


Fig. 24. Lenses of mica schist and amphibolite in biotite gneiss in saprolite exposure.

the fold axes strike almost E-W and plunge gently east; 1200 yards N73°W of Lithonia Post Office, small fold axes strike N10°W and plunge 10°N; along the ridge 500 yards S40°W of the Georgia Route 12-Klondike Road intersection, the fold axes strike N25°W and plunge 15°NW. South of Arabia Lake, the axes of several folds strike S50°E and plunge 10°SE. Figure 25 illustrates a typical example of the small folds in muscovite quartzite.

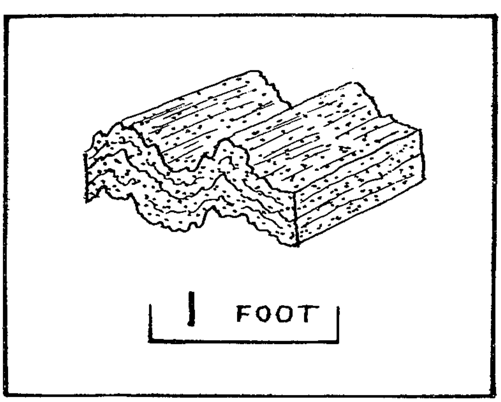


Fig. 25. Small folds in muscovite quartzite.

Numerous small folds from one to ten feet in amplitude occur in the gneisses southwest and south of Arabia Mountain. The axes plunge a few degrees to the northwest or southeast (Plate 3). The folds are generally but not always isoclinal.

The axis of a small fold in interlayered biotite gneiss and amphibolite (Fig. 26), located in a road cut 3200 yards S30°W of the crest of Stone Mountain, strikes N65°E and plunges 10°NE.

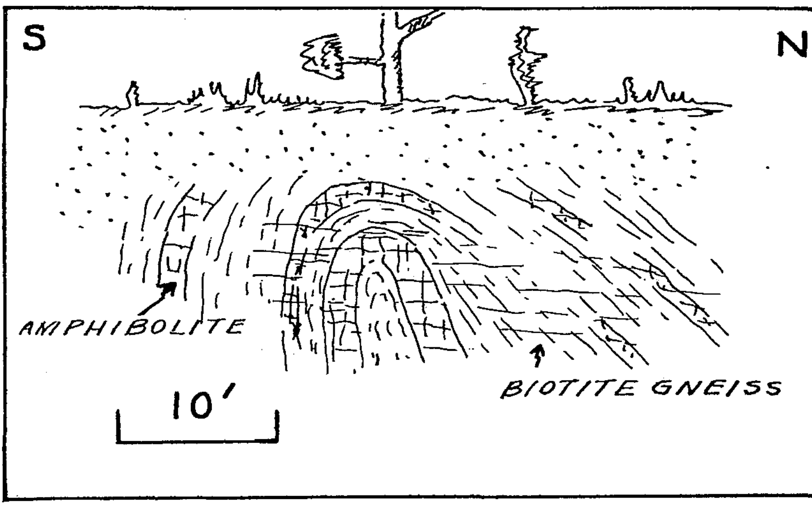


Fig. 26. Folded biotite gneiss and amphibolite in saprolite exposure.

Interlayered fine-grained biotite gneiss and amphibolite have been folded into a tight, nearly isoclinal overturned fold in a small stream 2200 yards S30°W of Centerville. The axis of the fold strikes S18°E and plunges 20°S. About 100 yards downstream the axes of other folds are erratic.

Longitudinal Folds

A detailed structure map of the area one and one-half miles N50°W of Arabia Lake (Fig. 27) shows that the mica schist and muscovite quartzite form a syncline overlying the Lithonia gneiss. Southwest of Rock Springs Church the syncline plunges gently to the north and the banding of the gneiss dips beneath the schist at low angles.

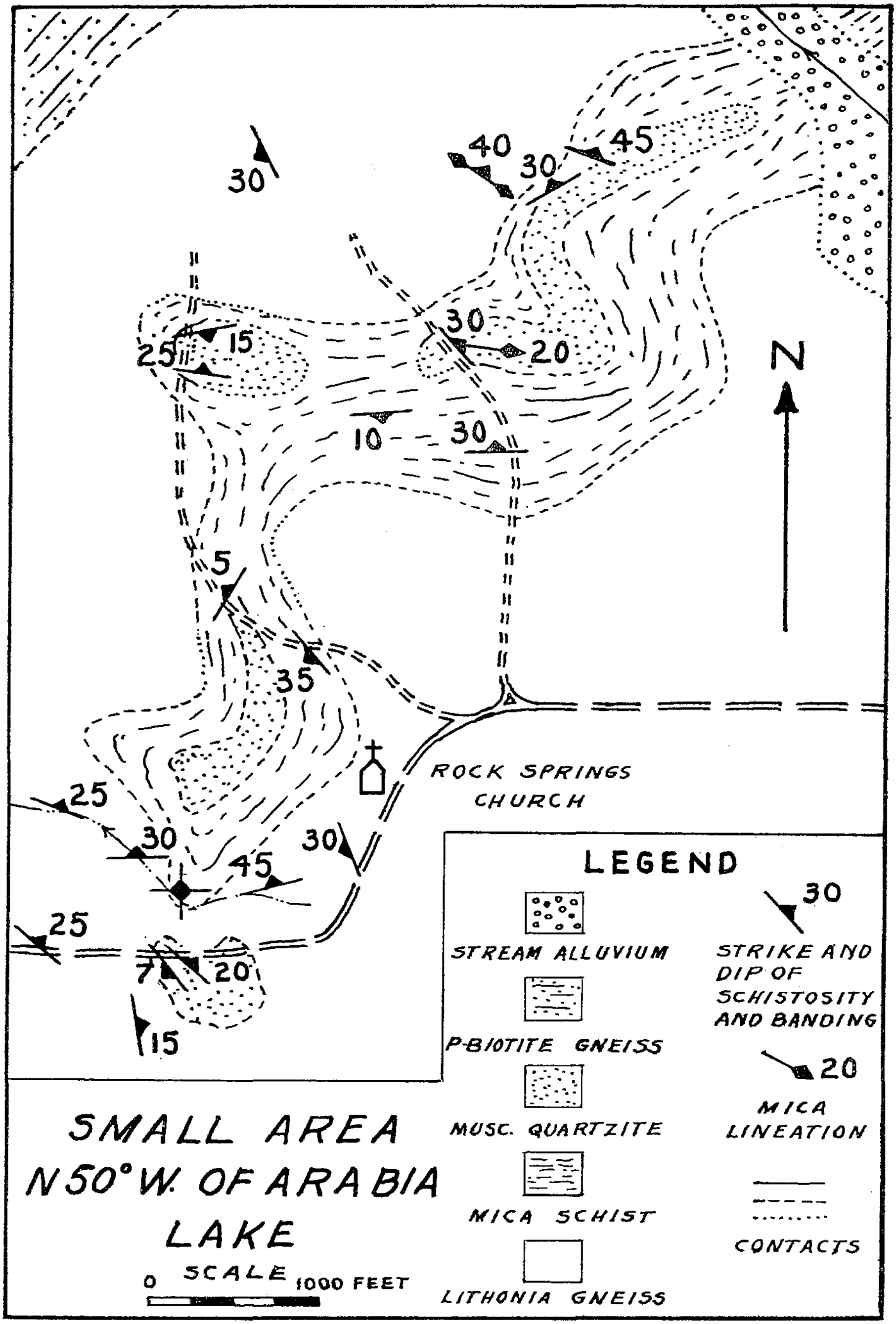

ROCK SPRINGS CHURCH
LEGEND
STREAM ALLUVIUM
P-BIOTITE GNEISS
MUSC. QUARTZITE
MICA SCHIST
LITHONIA GNEISS
STRIKE AND DIP OF SCHISTOSITY AND BANDING
MICA LINEATION
CONTACTS
SMALL AREA N 50° W. OF ARABIA LAKE
0 SCALE 1000 FEET
N

Fig. 27

The schist forms two synclinal troughs in the areas west and south of Arabia Mountain. The synclines and eroded anticlines (see sections D-D' and E-E', Plate 2) probably trended northeasterly prior to transverse folding.

Undulatory Folds

These folds, common throughout the district, are recognized by the rapid change in the attitude of the banding or schistosity within short distances. The fold axes strike perpendicular to the local trend of the rock in which they are found.

Transverse Folds

The metamorphic rocks of the district were gently uplifted on the western flank of the Lithonia gneiss and folded into broad, gentle anticlines and synclines. The limbs of the folds dip at low angles except in the area south of Arabia Mountain where they dip steeply to vertically. The fold axes plunge gently to the northwest except in the area west of Bermuda where they plunge to the north.

The best defined fold of the district is a broad syncline, southwest of Centerville, whose limbs can be traced for a distance of almost four miles along the crest of a small ridge of muscovite-quartz schist. The schistosity dips gently toward the trough of the syncline (Plate 2, section C-C').

Crenulations

The banding of the amphibolites in the northeast portion of the district is crenulated into small folds whose amplitudes range from a fraction of an inch to several inches (Fig. 28).

Lineations

The types of lineation in the metamorphic rocks can be divided into mica orientation (crenulations and/or stretching), fold axes (axes of major, minor, and undulatory folds), and hornblende orientation. A fourth, less pronounced, type is the orientation of garnet porphyroblasts in the garnet-mica schist.

The mica lineation is the best developed and most consistent type in the area. It is essentially the same as that found in the Lithonia gneiss, being either a stretching of mica

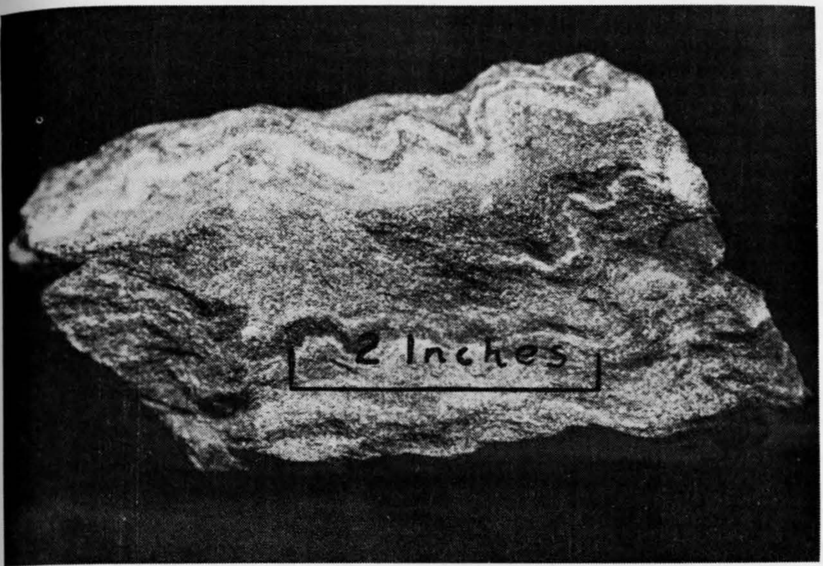


Fig. 28. Crenulations in amphibolite.

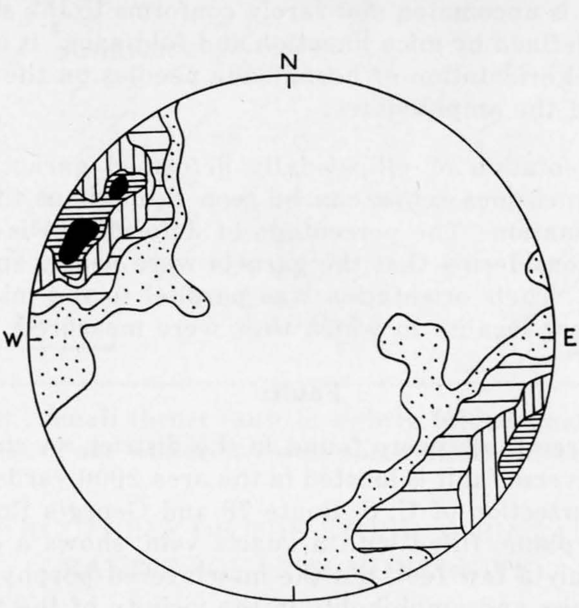


Fig. 29. Strike and plunge of one hundred and ninety-five mica lineations in the metamorphic rocks. Lower hemisphere of equal area projection. Contours 1-2-5-10-12%.

flakes on the banding or schistosity surfaces into ellipsoids (more nearly ellipses), or a slight crinkling or currugation of schistosity. This latter type is restricted to the garnet-mica schist. One hundred and ninety-five mica lineations measured in the schists and gneisses and plotted in the lower hemisphere of an equal area projection (Fig. 29) show a maximum strike of N65°W and plunge of 10°NW. This northwesterly trend can also be seen on the lineation map (Plate 3). The only place where this trend is not found is in the vicinity of Stone Mountain.

The axes of small folds in the muscovite quartzite, amphibolite, and in some of the interlayered gneisses are the only ones which can be measured in the field. The axes vary considerably in trend except in the southwest portion of the area (Plate 3) where they strike northwesterly. They, like the mica lineation, are most erratic in the vicinity of Stone Mountain granite intrusions.

Hornblende orientation is an unimportant type of lineation because it is uncommon and rarely conforms to the structural patterns defined by mica lineation and fold axes. It is formed by parallel orientation of hornblende needles on the banding surfaces of the amphibolites.

The orientation of ellipsoidally deformed garnet crystals in the garnet-mica schist can be seen throughout the extent of the formation. The percentage of deformation is as much as 50%, considering that the garnets were nearly spheroidal originally. Their orientation was parallel to the mica lineation in every locality in which they were measured.

Faults

Only three faults were found in the district. A steep, east dipping reverse fault is located in the area 2000 yards N20°W of the intersection of U. S. Route 78 and Georgia Route 141. The fault plane, filled with a quartz vein, shows a displacement of only a few feet, but the interlayered porphyroblastic biotite gneiss and amphibolite in the vicinity of the fault are highly brecciated.

A small, steeply dipping fault may be present in the area 2500 yards N22°W of the Norris Lake dam because a sequence of amphibolite and muscovite-quartz schist has been offset approximately 150 yards.

Four hundred yards north of Klondike, a small thrust fault has locally sheared the south limb of the muscovite quartzite syncline (Fig. 30).

Joints

Four hundred joints measured in the metamorphic rocks were plotted in the lower hemisphere of an equal area projection (Figure 31). The most pronounced joint set strikes N32°E and dips vertically. These joints are perpendicular to the regional mica lineations and transverse fold axes.

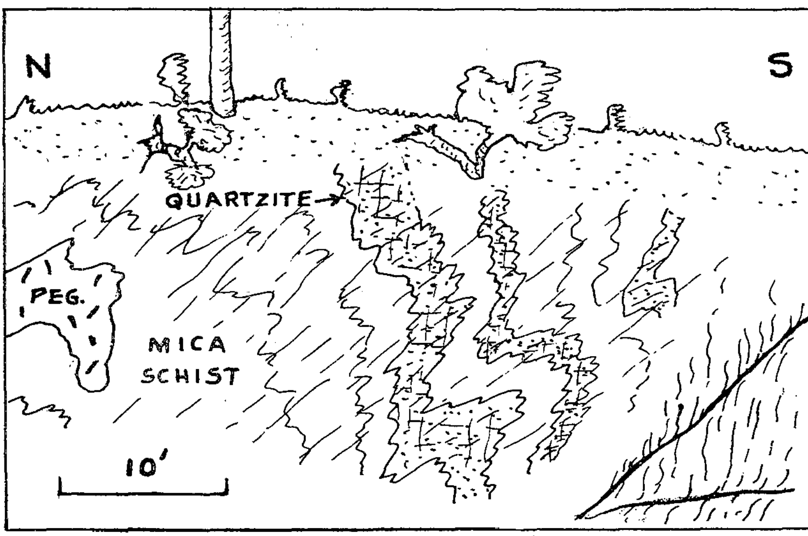


Fig. 30. Small thrust fault in tightly folded quartzite and mica schist. Four hundred yards north of Klondike.

STRUCTURES OF THE STONE MOUNTAIN GRANITE (QUARTZ-MONZONITE)

Flow Structures

The subparallel orientation of muscovite and biotite flakes in the Stone Mountain granite is termed flowage foliation in this report. The cross sectional shape of the pluton, as shown

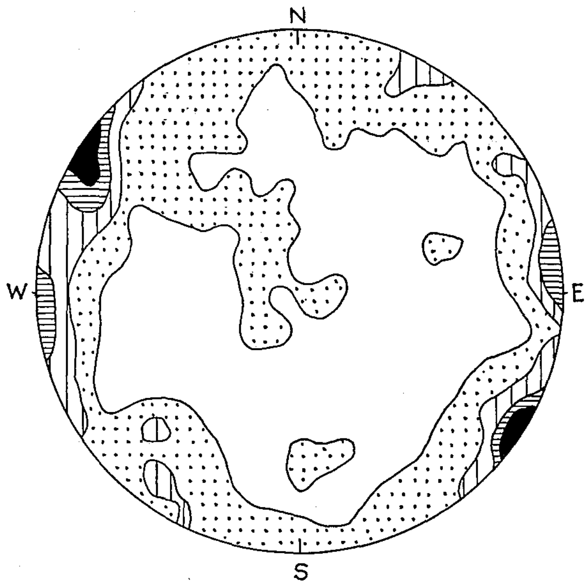


Fig. 31. Strike and dip of four hundred joints in the metamorphic series, plotted in the lower hemisphere of an equal area projection. Contours 1-3-5-6%.

by the foliation, is slightly asymetrical (See sections A-A' and B-B', Plate 2).

A pronounced foliation strikes approximately N10°W and dips from 10°-55°E in a small quarry on the northwest side of Stone Mountain (Figure 32). The foliation is accentuated by the parallel orientation of autoliths (Figure 33).

The attitude of the foliation changes progressively toward the southwest side of the mountain where it strikes N40°W and dips from 75°SW to 70°NW. On the south flank of the mountain the foliation varies (from W to E) from strike N70°W and dip 45°S to strike N30°E and dip 35°SE.

At numerous localities the foliation is indistinct. An alignment of mica flakes is visible on nearly horizontal pavement surfaces but not in surfaces perpendicular to the alignment. In these cases the mica is oriented about an axis of fluctuation as shown by mica girdles in diagrams M5 and M6, Plate 7.

Disc-shaped autoliths composed of muscovite and biotite

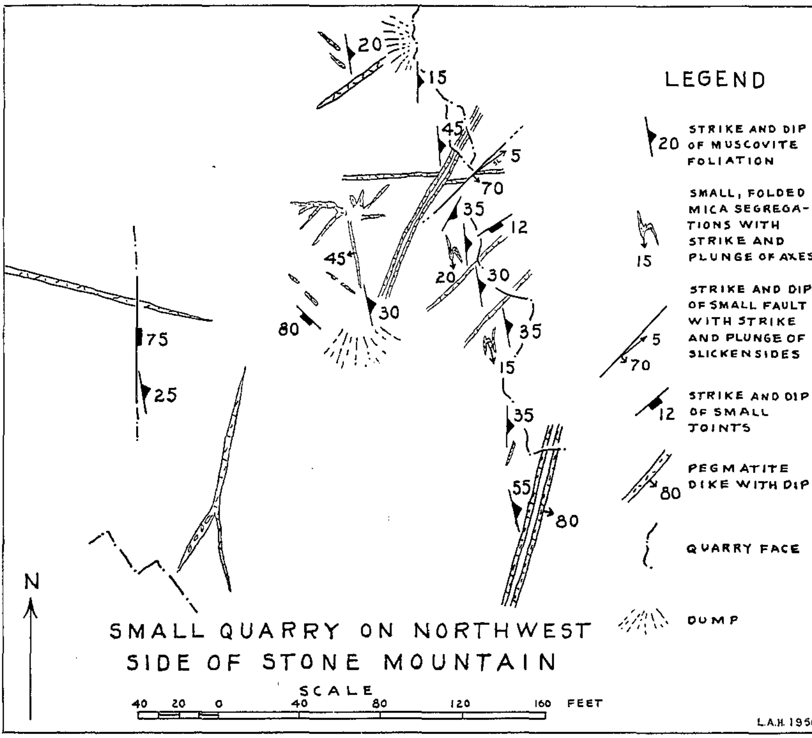


Fig. 32

with accessory garnet range from a few inches long and a fraction of an inch thick to about one foot long and several inches thick (Figure 33). They are often plicated parallel to the axes of mica fluctuation. Some of the autoliths contain large tourmaline crystals (Fig. 34).

Xenoliths

Numerous small, angular xenoliths of biotite-rich gneiss occur in the granite on the east side of Stone Mountain. They range in diameter from one to three feet. The banding of a xenolith which is partially surrounded by pegmatite (Fig. 35) is disharmonious with respect to the foliation of the granite.

Large and small xenoliths are found in a large granite dike which crosses Yellow River 3500 yards west of Centerville. The xenoliths range from small interlayered biotite gneiss and amphibolite blocks (Figure 36) to large areas of gneiss up to 1000 yards long.

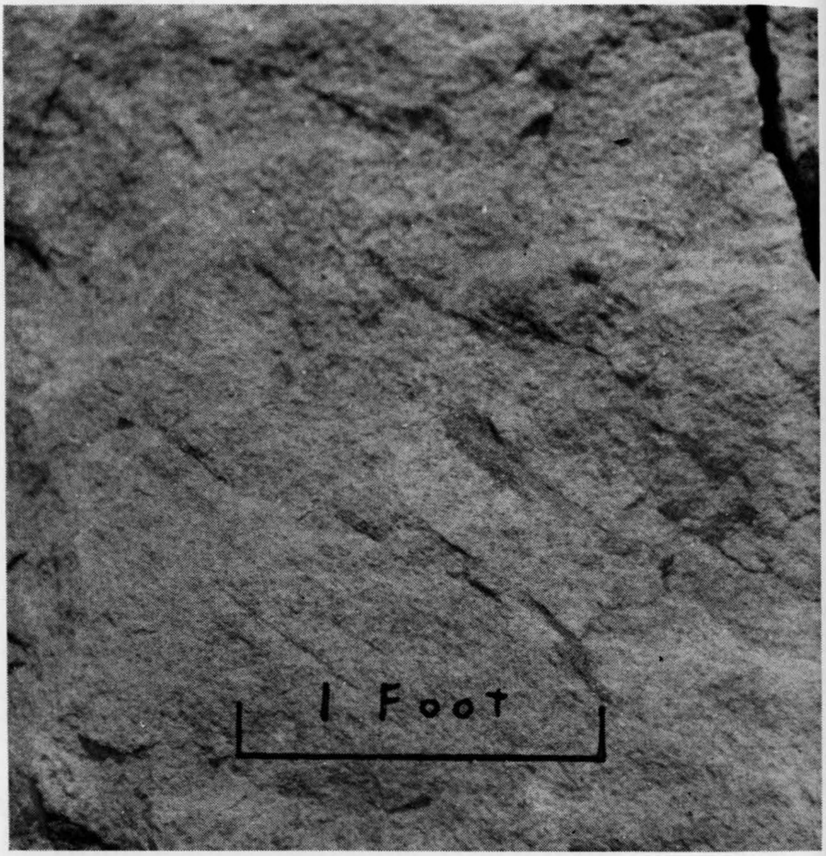


Fig. 33. Mica autoliths in the Stone Mountain granite.

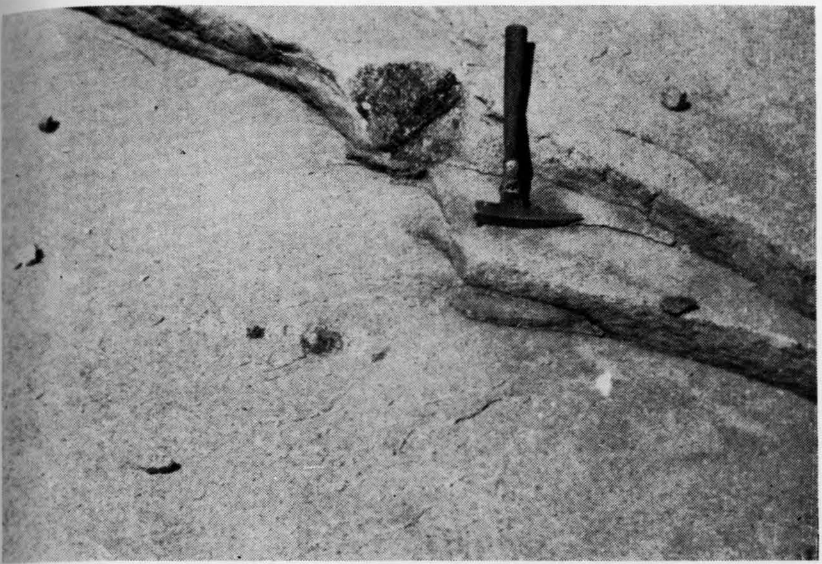


Fig. 34. Mica autolith containing a large tourmaline crystal.

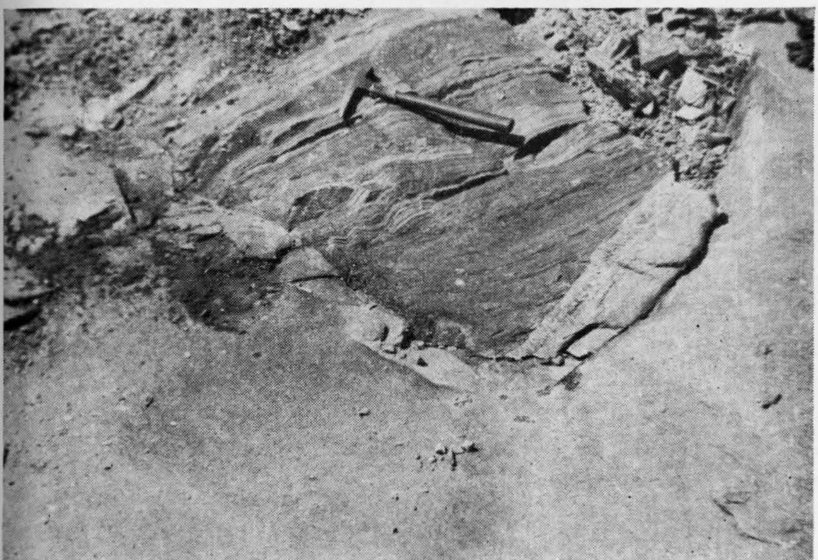


Fig. 35. Angular xenolith of biotite gneiss in the Stone Mountain granite.

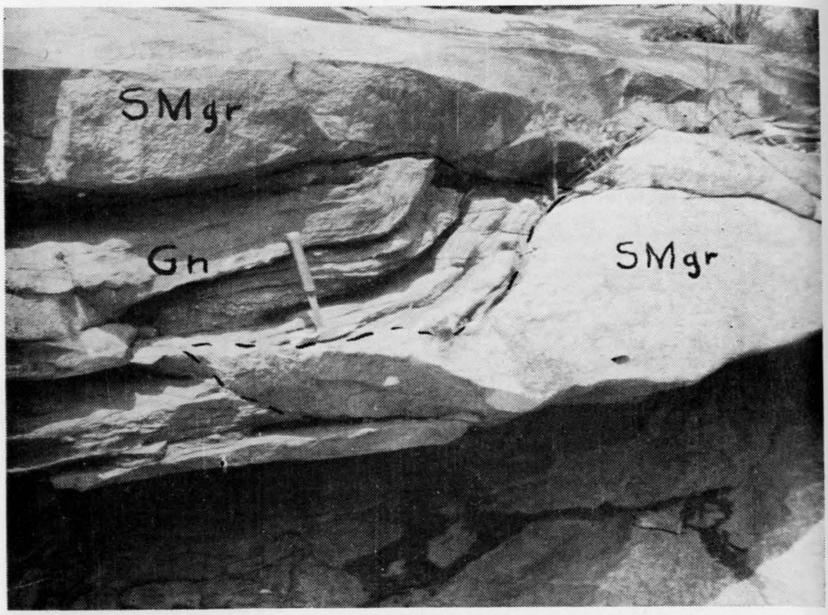


Fig. 36. Xenolith or interlayered biotite gneiss and amphibolite (Gn) in Stone Mountain granite (SMgr).

Tourmaline Clusters

Small, ellipsoidal clusters of tourmaline are scattered throughout the granite in the vicinity of Stone Mountain. They are often concentrated into zones parallel to the foliation (Figure 37).

Joints

Very few joints are found in the granite. However, of forty joints measured from the west side of Stone Mountain, a majority strike N55°W and dip from vertical to 65°NE. These are probably equivalent to the longitudinal joints discussed by Balk (1937, p. 34) as they strike nearly parallel to the foliation and dip steeply.

Nearly horizontal joints, or sheeting planes, are parallel to pavement surfaces, as in the Lithonia gneiss. Incipient fractures parallel to the sheeting are frequently found in quartz veins and quartz grains.

Fig. 37. Tourmaline clusters concentrated in a zone parallel to the foliation of granite.

RELATIONSHIP OF STRUCTURES TO DEFORMATION

General Statement

The structural interrelationships of the rocks of the Stone Mountain-Lithonia district can be summarized in a regional plan of deformation based on the structures of the district and on the regional trends obtained from the Geologic Map of Georgia (1939).

Coordinates of Deformation

The coordinate system of Sander (Cloos, 1946, p. 6) is used to designate the structural axes of the region and of the district under discussion. Thus, **b** is parallel to the regional axis of uplift which trends northeasterly, **a** is perpendicular to **b** in a nearly horizontal plane, and **c** is perpendicular to plane **a b.**

The coordinates of the Stone Mountain district are designated as **a′**, **b′**, and **c′**, where **b′** is parallel to minor and transverse fold axes, **a′** is perpendicular to **b′** in the plane of schistosity or banding, and **c′** is perpendicular to plane **a′ b′**.

The relationships between the two coordinate systems are $\mathbf{b} \perp \mathbf{b}'$, $\mathbf{a} \perp \mathbf{a}$, and $\mathbf{c} = \mathbf{c}'$. The coordinate **a** (= **b′**) is the regional direction of transport.

Major Axis of Uplift

On the Geologic Map of Georgia, the Lithonia gneiss covers an elongate area approximately 80 miles long in a north northeasterly direction. This northeast elongation is not apparent on the geologic map of the Stone Mountain-Lithonia district (Plate 1) because the overlying rocks have been folded into northwesterly trending transverse folds.

The major axis of uplift of the region, **b**, is considered to be parallel to the northeast elongation of the Lithonia gneiss. The longitudinal folds of the garnet-mica schist and muscovite quartzite are considered to have been originally parallel to this major axis of uplift.

Minor Axes of Uplift

Minor upwarps which developed on the western flank of the Lithonia gneiss folded the metamorphic rocks into a series of broad, open and gently plunging transverse anticlines and synclines, whose axes, **b′**, trend in a northwesterly direction. At the same time the upwarps refolded the originally northeasterly trending longitudinal folds of the garnet-mica schist and muscovite quartzite into transverse folds.

The axes of many small folds in the schists and gneisses are parallel to **b′**, but some, notably in the vicinity of Stone Mountain, are deflected from the regional trend, presumably by the intrusion of granite.

Mica Lineation

During the major uplift, the metasedimentary sequence above the Lithonia gneiss migrated westward (?) in the regional direction of transport, **a**, producing a strong mica lineation in the direction N60°W (Figure 29).

The mica lineation is assumed to be parallel to **a** because, according to Cloos (1946, p. 30), the amount of elongation possible parallel to fold axes is restricted, and depends upon the amount of arcuation of the fold axes during deformation. Thus, the extension parallel to the axes of the Appalachian Mountains rarely exceeds 10% (Cloos, 1946, p. 30), whereas the extension parallel to the direction of transport in the South Mountain fold, Maryland, is as much as 182% (Cloos, 1947, p. 907). The amount of elongation of garnets in the Stone Mountain area is as much as 50%, considering that they were originally nearly spheriodal in shape (See Cloos, 1947, pp. 861-865). The garnet elongation parallels the mica lineation and, consequently, parallels **a**.

Shear Zones

At a very late stage of deformation a pronounced set of shear zones was developed in the direction N25°E and a less pronounced set in the direction N40°W.

Joints

The most prominent joints of the district are parallel to the plane **a′c′**. They strike northeast, perpendicular to the direction of mica lineation.

RELATIONSHIP OF IGNEOUS INTRUSIONS TO DEFORMATION

The Stone Mountain granite commonly forms dikes in the crests of anticlines and dikes nearly perpendicular to the axes of northwesterly trending folds. For this reason it seems likely that the intrusions made use of breaks formed by tension in anticlinal crests and breaks formed perpendicular to fold axes.

The intrusions of the granite apparently produced additional deformation in the rocks which they intruded because the regional trend of fold axes and mica lineation is deflected in the vicinity of Stone Mountain.

Diabase dikes, the last rocks of the area to be formed, apparently followed a minor set of joints which trend north northwest.

PETROFABRIC ANALYSIS

Method

Six mica and five quartz fabric diagrams were prepared from six oriented rock samples (Plate 7); three of these samples are of the Lithonia gneiss, one sample is of the muscovite quartzite member of the mica schist-quartzite formation, and two samples are of the Stone Mountain granite.

A four axis Leitz universal stage mounted on a petrographic microscope was used to measure the orientation of cleavage poles of micas, and the optic axes of quartz grains in thin sections of oriented samples. The poles and axes were plotted in the lower hemisphere of an equal area projection, and the points were counted with one percent counter at intervals of less than one-half centimeter.

The diagrams in Plate 7 can be spatially oriented by means of small strike arrow and perpendicular dip line. The number on top of the arrow indicates the strike of the plane of the diagram; e. g., the number 32 means means a strike of N32°E, and the number 94 means a strike of S86°E. A number under the arrow of less than 90 indicates the diagram dips toward the reader, and a number greater than 90 indicates the diagram dips away from the reader; e. g., the number 85 means the diagram dips at an angle of 85° toward the reader and the number 95 means the diagram dips at an angle of 85° but away from the reader.

One section was cut from each oriented sample perpendicular to planar and/or linear structures. The sections were cut perpendicular to flow fold axes of the Lithonia gneiss, perpendicular to the mica lineation and foliation of the muscovite quartzite, and perpendicular to the axes of muscovite fluctuation in the Stone Mountain granite.

Fabric Diagrams

Three mica diagrams of the Lithonia gneiss (Plate 7, diagrams M1-M3) show nearly complete girdles about an axis which corresponds to the axes of flow folds in the gneiss. S_2-surfaces (Hills, 1943, pp. 149-152) parallel to megascopic banding are found in all three diagrams; and in addition, S_3-surfaces (microscopic foliation), oriented 30° counterclockwise from S_2, are found in diagrams M1 and M3.

In diagram M4 of the muscovite quartzite, two S_2-surfaces separated by an angle of 20° are bisected by the megascopic foliation.

The axes of mica girdles in diagrams M5 and M6 of the Stone Mountain granite correspond to megascopic axes of muscovite fluctuation. S_2-surfaces (mica maxima) are parallel to megascopic flowage foliation.

Quartz diagrams of the Lithonia gneiss (Q1-Q3) contain partial to complete girdles which correspond to the mica girdles. Maxima 4, 5, and 7 of Fairbairn (1949, p. 10 Figure 2-1) are also found in these diagrams.

Diagram Q4 of the muscovite quartzite shows maxima 1 of Fairbairn.

Diagram Q5 of the Stone Mountain granite shows a quartz girdle and also maxima 2 of Fairbairn.

Discussion

Oriented samples of Lithonia gneiss, muscovite quartzite and Stone Mountain granite were selected for petrofabric study to establish the relationship between the megascopic and microscopic structures of these rocks.

PLATE 7

Petrofabric Diagrams

Sample No.	Diagram	Mineral	No. of Grains	Contours (%)
L4(C)	M1	Biotite	65	1-2-4-7
L21(1)	M2	Biotite	170	1-2-4-6-10
L117(5)	M3	Biotite	118	1-2-5-8
C785	M4	Muscovite	90	1-3-6-10-15
C62(11)	M5	Muscovite	106	1-2-4-5
A208	M6	Muscovite	150	1-2-4-6
L4(C)	Q1	Quartz, large	94	1-3-5
L21(1)	Q2	" "	100	1-3-5
L117(5)	Q3	" "	138	1-2-4
C785	Q4	Quartz, strained	90	1-3-6-9-11
S62(11)	Q5	Quartz, large	114	1-2-4-7-10

L4(C)—Lithonia gneiss from a small quarry 300 yards S12°W of Lithonia.

L21(1)—Lithonia gneiss from the A. G. Wilson quarry, 1600 yards N20°W of Lithonia.

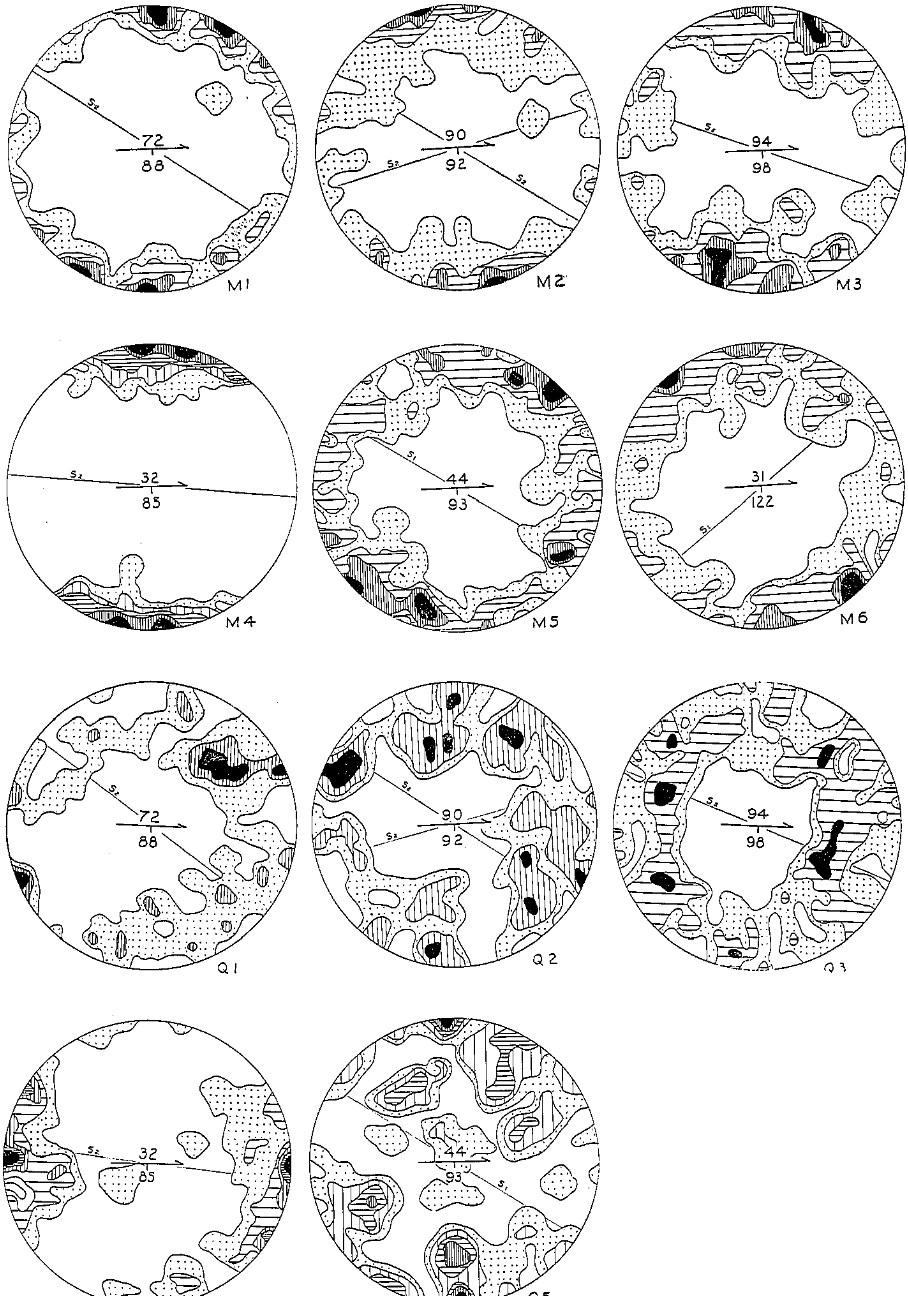
L117(5)—Lithonia gneiss from the Chapman quarry, 2800 yards N10°W of Lithonia.

C785—Muscovite quartzite from a ridge 1200 yards N75°W of Norris Lake dam.

S62(11)—Stone Mountain granite from Flat Rock quarry, 1200 yards N30°E of the crest of Stone Mountain.

A208—Stone Mountain granite from the south side of the mountain.

PLATE 7


72
88
M1
90
92
M2
94
98
M3
32
85
M4
44
93
M5
31
122
M6
72
88
Q1
90
92
Q2
94
98
Q3
32
85
Q4
44
93
Q5

Fabric diagrams of muscovite and quartz in Stone Mountain granite reveal girdles and S_2-surfaces. These fabrics verify megascopic structures such as flowage foliation and axes of muscovite fluctuation which were measured in the field.

The fabric diagrams of mica and quartz in specimens of Lithonia gneiss reveal mica and quartz girdles whose axes are parallel to axes of flow folds measured in the field. The diagrams also contain S-surfaces, one which (S_2) is parallel to the megascopic banding, and the other (S_3) which is oriented 30° counterclockwise from S_2. The S_3-surface may represent a plane formed by rotation during folding which is not always identifiable megascopically.

The intersection of the S_2-surfaces in the mica diagram of muscovite quartzite (M4) is parallel to the mica lineation measured in the field. In addition to being stretched, the muscovite is slightly rotated out of the megascopic foliation plane. The C-axes of quartz in the quartz diagram (Q4) are oriented perpendicular to the mica lineation and down the dip of the megascopic foliation. The meaning of this orientation is not known.

PETROGENESIS

ORIGIN OF THE LITHONIA GNEISS

General Statement

Three samples of highly contorted Lithonia gneiss (Table 6), analyzed by T. L. Watson, had chemical compositions of silica-rich granites. The writer sampled the gneiss in more detail to determine local changes in composition.

Banding and Garnetiferous Layers

The explanation of the origin of the banding of the Lithonia gneiss must take the following features into consideration: (1) the concordance of the contact of the Lithonia gneiss with the schistosity of the overlying mica schist; (2) the conformity of the banding of the Lithonia gneiss to the contact with the mica schist; (3) the presence of quartz-rich garnetiferous layers within the Lithonia gneiss whose banding is usually parallel to that of the gneiss; and (4) the presence of drag-folded layers within the Lithonia gneiss.

Neither discordant nor disconformable relationships exist in any locality in which the contact was observed. Thus, an igneous origin of the banding is very unlikely, for as Daly (1914, p. 99) states, "a leading characteristic of stock or batholith is that its contact-surfaces usually truncate the planes of stratification or schistosity of the invaded formations".

Lester (1939, pp. 841-847) discussed the origin of the garnetiferous layers in the Lithonia gneiss and concluded that they were segregations of a granite magma. He stated (p. 847) that "the segregations are therefore considered to be the result of convection currents in a differentiating magma, rising almost vertically and bringing up garnet bands which were fractured and faulted by a shifting of the mass shortly before final consolidation". He gave no detailed petrographic description of the layers, although he did state that "the mineral within the limits of the width of the individual band is entirely garnet; but several bands of garnet may form the segregation band, and between the garnet bands is found granite gneiss" (p. 845). However, only a trace of potash feldspar was found in the light bands between garnet bands in four thin sections of garnetiferous layers studied by the writer. Thus, the light bands between garnet bands are not granite gneiss. Furthermore, the light bands between garnet bands are rich in free quartz (Table 1, S150(5)). The rock has a granoblastic texture, common in metasediments but rare in igneous rocks.

The abundance of free quartz in the garnetiferous layers would exclude the possibility that they were differentiated from a magma.

The lack of intrusive phenomena at the contact between the Lithonia gneiss and the overlying mica schist, and the lack of inclusions of mica schist within the Lithonia gneiss make it seem unlikely that the garnetiferous layers are recrystallized xenoliths.

The writer believes the quartz-rich garnetiferous layers are the recrystallized equivalents of impure argillaceous quartzite beds of an original sedimentary formation. Drag-folded layers in the gneiss at Mile Rock (Figure 20; Figure 21) may be relic beds of the same sedimentary formation, but this cannot be confirmed.

The fact that the banding of the Lithonia gneiss is conformable to the concordant contact with the mica schist, and the fact that the banding usually is parallel to the banding of quartz-rich garnetiferous layers of probable sedimentary derivation, suggests that the present banding of the Lithonia gneiss is parallel to the bedding of a sedimentary formation prior to metamorphism. The original formation probably consisted of a thick sequence of thinly laminated argillites with local, thicker, impure argillaceous quartzite layers. Metamorphism completely recrystallized the rock, changing the bedding to banding.

Shearing during deformation of the region further obliterated the original bedding. Finally, the introduction of magmatic (aplitic) material along the banding emphasized the banded nature of the highly altered rock.

Potash Metasomatism

The introduction of syntectonic aplite veins which form an intimate part of the gneiss was accompanied by replacement. The replacement was one of potash metasomatism. Potash-rich (aplite) solutions attacked and replaced oligoclase and biotite forming muscovite with associated quartz, epidote, and calcite (Figure 7). The amount of muscovite which formed probably depended on the MgO:FeO available from the replacement of biotite. After this ratio was satisfied, the remaining potash-rich solutions formed the microcline which also replaced oligoclase (Figure 8) and muscovite.

The replacement of oligoclase by muscovite and microcline caused a release of calcium and sodium into the system equal to the amount contained in the replaced oligoclase. The excess calcium has gone into two new phases, epidote and calcite; and the excess sodium has caused an overall increase in the albite molecule of the plagioclase (Figure 11).

Potash metasomatism is also shown by chemical analyses of the gneiss from several localities. Three samples of well banded gneiss from the interior of the mass (Table 6, nos. 1, 2, and 3) show a high percentage of K_2O, whereas two samples from near the contact with mica schist show a low percentage of K_2O (Table 6, nos. 4 and 5).

TABLE 6

Chemical Analyses* of the Evenly Banded Phase of the Lithonia Gneiss

	(1)	(2)	(3)	(4)	(5)
SiO_2	76.00	75.16	72.96	72.83	69.66
Al_2O_3	13.11	13.74	14.70	17.71	17.42
Fe_2O_3 / FeO	0.92	0.91	1.28	2.29	3.92
CaO	1.06	0.91	1.28	1.88	3.63
MgO	0.27	0.17	0.07	0.75	1.32
K_2O	4.69	5.05	4.73	1.90	0.76
Na_2O	3.88	3.76	4.18	2.12	2.58
SO_3	--------	--------	--------	--------	0.72
Ignition	0.31	0.32	0.23	0.00	0.00
Undetermined	--------	--------	--------	0.50	0.00
Total	100.24	100.02	99.43	99.98	100.01

*Analyses 1-3 obtained from Watson (1902, p. 355). Analyses 4 and 5 performed in 1951 in the Laboratory of the Georgia Department of Mines by L. H. Turner, Chief Chemist.

(1)—Lithonia gneiss from the Coffey quarry on Mile Rock, west of Arabia Mountain (formerly the Crossley quarry).

(2)—Lithonia gneiss from Arabia Mountain.

(3)—Lithonia gneiss from the Davidson Brothers Quarry, located one mile north of Lithonia, Ga. (Formerly the Southern Granite Co. Quarry).

(4)—Evenly banded Lithonia gneiss from a small quarry near the contact with mica schist, approximately 500 yards west of Arabia Lake.

(5)—Partially weathered, evenly banded Lithonia gneiss from Evans Mill, just south of the dam (one and one-half miles west of Arabia Lake).

Migmatization

According to Sederholm (1907, p. 110), a migmatite is a mixed rock composed of an older gneiss (or schist) injected by later granitic magma. The Lithonia gneiss conforms to this definition in that it has been intimately injected by syntectonic aplite veins. The introduced aplite has altered the rock into a granite (compositionally) by addition and metasomatism.

The change in composition from a normal biotite-rich gneiss into a well-banded biotite gneiss with a granitic composition by the introduction of granitic (aplite) solutions is illustrated in Figure 38. The ratio of oligoclase to microcline, recalculated to 100%, is plotted against the anorthite content of oligoclase. The biotite-rich phase contains a high percentage of oligoclase (An_{15}-An_{17}) and a low percentage of microcline. The aplite phase contains a low percentage of oligoclase (An_{10}) and a high percentage of microcline. The well-banded phase contains an intermediate percentage of oligoclase (An_{11}-An_{14}) and microcline, as would be expected if the biotite-rich and aplite phases were mixed.

The ultimate limit of the migmatizing process may have been the complete melting of the gneiss locally (partial anatexis, Eskola, 1933, p. 12) forming intrusive granite dikes. The evidence for this phenomenon can be seen in the Davidson Brother's Big Ledge Quarry, one-half mile north of Lithonia, in which massive granite dikes (Figure 39) of the same mineralogical composition as the gneiss are intrusive in the gneiss.

The origin of the Lithonia gneiss corresponds very strikingly to the origin of the rocks in Eskola's crustal zone no. 2 (1933, pp. 23-24). According to him (pp. 23-24) it is "the zone of intrusions and of injection and potash metasomatism. - - - The invaded rocks are increasingly changed in composition by the introduction of granitic material, mainly ap-

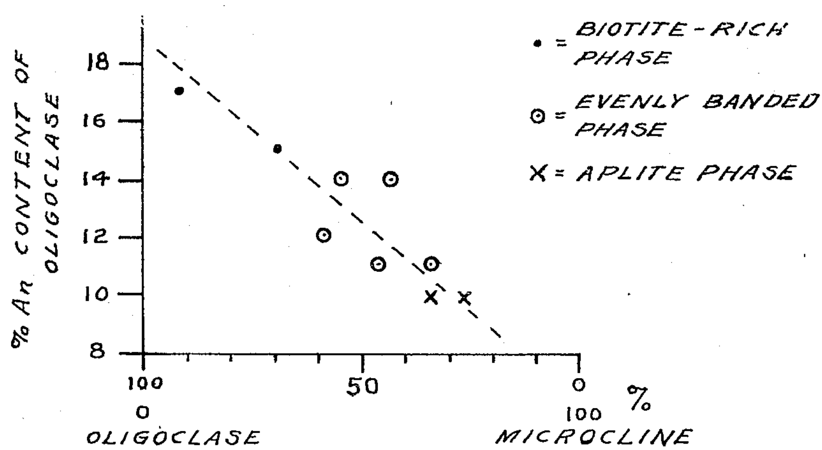


Fig. 38. Variation diagram showing the change in feldspar content between several phases of the Lithonia gneiss. Ratio of oligoclase: microcline recalculated to 100%.

pearing as a potash metasomatism, and imbibition with potash feldspar. Rocks close to granites in composition may be granitized - - -".

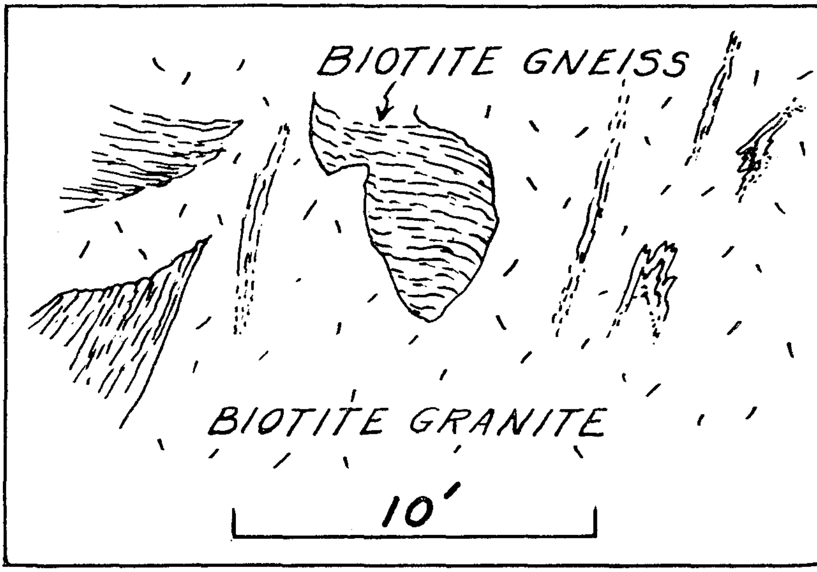


Fig. 39. Homogeneous granite dike intruded into the Lithonia gneiss at the Big Ledge Quarry.

ORIGIN OF THE AMPHIBOLITES

General Statement

Any explanation of the origin of the amphibolites of the Stone Mountain-Lithonia district must take into account the following features: (1) The presence of concordant amphibolite layers and lenses throughout the metamorphic series; (2) The conformability of the banding of the amphibolites with the banding of the enclosing rocks; (3) The wide range in size of the individual amphibolite layers; (4) The nearly uniform chemical composition of the amphibolites throughout the district; and (5) The abundance of partially rounded sphene grains in the amphibolites.

The chemical analyses of three amphibolite samples from widely separated localities are given in Table 2, nos. C79, C1486, C1060. These analyses show that the bulk composition of the amphibolites changes very little throughout the area. Nor does the composition show any change at various distances from the contact of the Lithonia gneiss. They must, therefore, have approximately the same composition at the present time that they had prior to metamorphism.

Igneous Origin

The possibility that the amphibolites were originally basic igneous sills in the metamorphic series seems valid in light of their chemical composition, although one would expect to find more evidence of discordant contact relationships.

If the amphibolites were originally igneous flows or ash deposits, the conformable structures and uniformity in composition could be explained. However, the presence of amphibolites throughout the metamorphic series would necessarily entail the continuance of volcanic activity throughout a long period of geologic time. The abundance of partially rounded sphene grains in the amphibolites argues for transport and deposition regardless of the nature of the parent material.

Sedimentary Origin

The theory of formation of amphibolites by the metamorphism of sedimentary rock has gained considerable favor among geologists in the past decade. Adams and Barlow (1910) concluded that some of the amphibolites of the Haliburton and Bancroft Area, Ontario, were formed by metamorphism of limestone under the effects of an intruding granite batholith. They state (p. 104) that "the crystalline limestone can be seen, under the influence of the granite intrusion, to have changed into a typical hornblende feldspar amphibolite, passing through the intervening stage of a pyroxene scapolite-hornblende feldspar amphibolite (pyroxene scapolite gneiss)".

More recently Kesler (1944), in a study of the Kings Mountain Area, North Carolina, found the following gradation away from a granite contact: (1) schist with interlayered hornblende gneiss; (2) a series of carbonate-silicate rocks; (3) limestone. He concluded that the mafic silicate rocks were originally carbonate rocks of the Gaffney formation completely reconstituted by granitic emanations (pp. 777 and 778).

In the Stone Mountain area there is no evidence of the formation of amphibolites by reconstitution of carbonate rocks; however, there is no reason why they could not have originated from the metamorphism of sedimentary rocks of appropriate chemical composition. For example, a Carboniferous shale from Elliott County, Kentucky (Table 7) has a composition similar to that of the amphibolites of the Stone Mountain area (cp. analyses C79, C1486, C1060, Table 2). However, from a total of 60 samples of shales and slates, only the above shale approaches the composition of the amphibolites.

TABLE 7

Chemical Analysis of a Carboniferous Shale*

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO
41.32	20.71	2.59	5.46	1.91	9.91	7.19	0.88	0.48	0.08	0.17

*"analysis of an indurated Carboniferous shale in contact with the peridotite dike of Elliott Co., Ky." (Clark, F. W., *Analyses of Rocks—1880-1903*. U. S. Geological Survey Bull. 228, 1904, p. 343.)

ORIGIN OF THE BIOTITE-HORNBLENDE GNEISS

The biotite-hornblende gneiss grades into amphibolite along its strike, 1700 yards N45°W of Bermuda. Hence, it may be a facies (igneous or sedimentary) of the amphibolites.

However, the formation of a moth-eaten texture in the hornblende grains by embayment of plagioclase, quartz, biotite, and/or epidote indicates that the biotite-hornblende gneiss may have been formed by partial replacement of a hornblende gneiss by silica-rich solutions.

ORIGIN OF THE STONE MOUNTAIN GRANITE

The igneous (intrusive) origin of the Stone Mountain granite is shown by its uniformity in mineralogical composition (Table 5), the formation of numerous, discordant dikes, and the conformity of its flow structures to the discordant contacts with the intruded gneiss.

METAMORPHISM

GENERAL STATEMENT

The metamorphic rocks of the district are placed in either the staurolite-kyanite or the sillimanite-almandine subfacies of the amphibolite facies (Turner, 1948, pp. 81 and 85) on the basis of the index minerals hornblende, pyroxene, epidote, plagioclase, sillimanite, and kyanite. The schists and gneisses immediately surrounding the Lithonia gneiss were progressively metamorphosed from the regional staurolite-kyanite level to the sillimanite-almandine level. The line which divides these two subfacies is estimated to lie between the last occurrence of epidote and the first occurrence of pyroxene in the amphibolites, and the last occurrence of kyanite and the first occurrence of sillimanite in the mica schist-muscovite quartzite series.

STAUROLITE-KYANITE SUBFACIES

The index minerals for this subfacies are hornblende, epidote, plagioclase, and kyanite. Epidote, although not a normal phase of the amphibolite facies, is stable in the epidote amphibolites by virtue of the high $CaO:Na_2O$ ratio (13:1). This relationship is brought out by Turner (1948, p. 82) who states, "from the very nature of the parent rocks [amphibolites], biotite and quartz are inconspicuous, while the ratio $CaO:Na_2O$ may be sufficiently high to cause the appearance of epidote or zoisite as an additional phase." The amount of CaO above that used in the formation of andesine is taken up largely in the formation of epidote.

SILLIMANITE-ALMANDINE SUBFACIES

The index minerals for this subfacies are hornblende, diopside, sillimanite, and plagioclase.

MINERALOGICAL CHANGES DURING PROGRESSIVE METAMORPHISM

In addition to the transition from kyanite to sillimanite in mica schist, hornblende, epidote, pyroxene, and plagioclase of the amphibolites show diagnostic changes as a result of progressive metamorphism. Inasmuch as the amphibolites retain a fairly consistent chemical composition throughout the area (Table 2, Nos., C79, C148, and C1060) any mineralogical changes in them must have been the result of internal reconstitution.

Hornblende shows a decrease in the size of 2V from 75° to 69° and an increase in the index of refraction, $N\gamma$, from **1.666** to **1.677**; diopside ($Di_{65}He_{35}$) substitutes for epidote; and plagioclase changes from sodic to calcic andesine in the transition from epidote to pyroxene amphibolite.

According to Sundius (1946, Figures 8 and 10) the above changes in optical properties of the hornblendes indicate a decrease in Mg and an increase in the percentage of Fe″ and Fe″′ in the transition from the staurolite-kyanite to the sillimanite-almandine subfacies. The release of Mg into the system could be utilized in the formation of diopside.

The excess calcium which is released by the transition from epidote to diopside is accounted for by the increase in the anorthite content of the plagioclase in the pyroxene amphibolites.

Biotite shows very little change in composition regardless of the metamorphic grade of the rocks in which it occurs.

CAUSES OF METAMORPHISM

The metamorphic rocks of the district are thought to represent original sediments which have been highly deformed. The high degree of deformation is evident in the longitudinal and transverse folds of the metamorphic rocks, the obliteration of bedding, the formation of schistosity and banding, and the regional metamorphism to the staurolite-kyanite amphibolite subfacies.

Increased temperature and stresses probably gave rise to the regional metamorphism because, according to Turner (1948, p. 81), the main cause of metamorphism to the staurolite-kyanite subfacies is "strong deformation under high pressure and shearing stress".

Renewed deformation of the region by uplift of the Lithonia gneiss folded the previously formed schistosity and banding. This deformation, which perhaps took place during the Appalachian Revolution, was accompanied or followed by the migmatization of the Lithonia gneiss by emanations from a deep-seated magma which is represented by the Stone Mountain pluton and aplite and pegmatite dikes. The heat evolved from this magma progressively metamorphosed the rocks surrounding the Lithonia gneiss from the staurolite-kyanite to the sillimanite-almandine amphibolite subfacies.

The migmatizing solutions were not entirely limited to the Lithonia gneiss. The mica schist was considerably altered in the area south of Arabia Mountain where pegmatitic veins changed the schist into an augen gneiss. In places the schist grades into a rock which very closely resembles the Lithonia gneiss, even to the extent of containing shear zones.

GEOLOGICAL HISTORY AND CONCLUSIONS

The migmatitic and metasedimentary rocks of the district are thought to have been originally deposited as a thick sedimentary sequence. The Lithonia gneiss was perhaps deposited in a basin of moderate depth as thinly bedded sandy to argillaceous sediments with occasional thicker impure argillaceous sandstone layers. The mica schist-quartzite formation was deposited conformably over the Lithonia sediments as a sequence of shales and sandstones that contained some argillaceous sandstones, shales, and possibly volcanic flows or ash deposits. The deposition probably took place in pre-Cambrian time.

Deformation (during the pre-Cambrian ?), coupled with an increase in temperature, metamorphosed the rocks to the kyanite grade. This deformation and recrystallization might have produced the secondary planar structures, schistosity and banding. Relic bedding may be preserved in the form of compositional interlayering.

Renewed deformation in the form of uplift of the Lithonia gneiss is believed to be Appalachian in age because the major axis of uplift, **b**, is approximately parallel to the trend of the Appalachian Mountains.

Longitudinal northeast trending folds in the mica schist-quartzite formation were refolded into transverse northwest trending folds. At the same time the other metamorphic rocks were also deformed into transverse folds.

During deformation, the Lithonia gneiss was injected and replaced by syntectonic, magmatic, potash-rich solutions. This process altered the Lithonia gneiss into a well-banded granite (in composition). Relics of the original bedding probably remain as quartz-rich garnetiferous layers parallel to the gneissic banding. The banding was contorted into minor folds which trend in a northeasterly direction.

Potash-rich solutions from an underlying magma produced a thermal metamorphic aureole around the Lithonia gneiss. This increased the metamorphic grade from the staurolite-kyanite to the sillimanite-almandine subfacies of the amphibolite facies.

In a late stage of the uplift, the Lithonia gneiss and its garnetiferous layers were sheared along a pronounced set of shear zones trending N25°E and a less pronounced set trending N40°W.

Movement perpendicular to **b** produced a strong mica lineation in the Lithonia gneiss and in the metamorphic series. This lineation, **a**, trends in a northwesterly direction, parallel to minor fold axes.

The Stone Mountain granite intruded the metasediments after the major deformation had been completed. The granite not only lacks the regional mica lineation, but actually deflects the lineation in the vicinity of Stone Mountain. Because the intrusion may have taken place at a late stage of the Appalachian deformation, it is tentatively assigned a Permian age.

A major set of cross joints (**a′c′**) is perpendicular to the mica lineation. Triassic diabase dikes were intruded parallel to northwest trending joints. The diabase dikes are assumed to be Triassic in age because of their similarity with dikes of known Triassic age in other regions, and also because they intrude the Stone Mountain granite (Permian?) but fail to intrude the Cretaceous sediments of the Georgia Coastal Plain.

Quaternary alluvium is still being deposited as stream gravels.

Mica and quartz fabric diagrams substantiate structural data measured in the field.

THE STONE INDUSTRY

HISTORY

The rock types of the district suitable for building and monumental stone attracted attention early in the history of the region because of their hard, unweathered surfaces. The natural ledges caused by sheeting* simplified quarrying but their partially weathered sap surfaces (Watson, 1902, p. 326) made the rocks unsuitable for purposes other than foundation stones, chimneys stones, and steps. The desire for hard, unaltered stone, unobtainable from the natural ledges, led to the method of raising ledges of any desired thickness by artificial means (see Quarrying Methods). The ability to raise ledges has been one of the major factors in the early and continued success of the stone industry.

Few records of quarrying in the region date back very far, but Watson (1902, p. 111) noted that tombstones were made about 1845 or 1850 and that some stone was quarried from Stone Mountain prior to the Civil War. The Stone Mountain Granite and Railway Company and their successors, the Venable Brothers, who operated quarries on Stone Mountain beginning in 1869, were the first to produce stone on a large scale. During their peak production the Venable Brothers quarried 20,000 carloads of stone from two large quarries on the south side of Stone Mountain. The output was transported from the quarries to the Georgia Railway on a spur which ran around the west side of the mountain.

Prior to 1900 the Venable Brothers also owned a large portion of the exposed rock (Lithonia gneiss) in the vicinity of Lithonia. Their major holdings were Little Stone Mountain (Pine Mountain) and most of Arabia Mountain. Pine Mountain was first worked in 1883 according to Watson (1902, p. 142) and by 1900 was supplying a large quantity of Belgian blocks, curb stone, road ballast, and dimension stone.

At the beginning of the 20th Century there were no major stone producers in the area other than the Venable Brothers. The Southern Granite Company owned a five acre quarry at the present site of the Davidson Granite Company's Big Ledge

*Sheeting is the term used to describe the nearly horizontal joints of granites and similar rocks.

Quarry and also owned the Collinsville Mountain Quarries. The Georgia Railroad owned a quarry on the exposure southwest of Little Stone Mountain and, in addition, owned a quarry in conjunction with Mrs. Mary Reagin located near the DeKalb-Rockdale County line, just north of the railroad tracks.

Quarrying of the Stone Mountain granite declined after 1900 due to lessened demand for this type of stone. The decline was not due to lack of beauty but rather to the inability of the stone to stand up under prolonged weathering. Weathering causes the surface of building blocks to change color from a sparkling white to a dull gray, and causes the surface of polished monumental stone to lose much of its luster. On the other hand, the demand for Lithonia gneiss increased because of its hardness and color retaining quality, and the abundance of easily accessible stone in the Lithonia area.

The Venable Granite Company was succeeded in Lithonia by the Davidson Granite Company, started in 1895 by J. K. Davidson, Sr. Mr. Davidson immigrated from Scotland and began work as a quarry laborer, but in a few years he was in business for himself. During the first year of operation he produced a relatively small number of paving blocks from quarries leased at Collinsville Mountain; but from these meager beginnings he built the business into a large enterprise which now produces all of the dimension stone of the district and much of the rubble, curb stone, crushed stone, and jetty stone. He also pioneered in the manufacture of poultry grit which, according to experiments of the Quaker Oats Company, aids in the assimilation of feed by grinding it more thoroughly. A large plant at the site of the Big Ledge Quarry is used solely for the production of poultry grit and crushed stone. The old plant burned down in the late spring of 1950 and was replaced by a new, modern plant. The company is now owned by Mr. Davidson's sons.

In 1950, the company owned approximately 1500 acres of exposed gneiss in the vicinity of Lithonia. Their main property is the Big Ledge Quarry, previously owned by the Southern Granite Company, to which has been added the adjoining Abrams and Braswell properties. The Davidson Granite Company succeeded the Venable Brothers as owners of the

Pine Mountain and Arabia Mountain Quarries. From the Big Ledge and Pine Mountain Quarries comes the total dimension stone, curb stone, and jetty stone production of the company.

In 1900 there were small crushing plants at the Georgia Railroad and Pine Mountain quarries to convert the quarry waste into road metal and ballast, but the small demand for crushed stone at that time did not warrant the operation of a separate quarry for this purpose. With the advent of the automobile more and better roads were needed. To supply this need the Consolidated Quarry Corporation opened a quarry at Rock Chapel Mountain in April, 1929, which produced 150,000 tons of stone the first year. Production from this plant increased to over 1,000,000 tons of crushed stone in 1949 under the direction of Nelson Severinghaus, vice-president and general manager.

The Davidson Granite Company crushing plant at the Big Ledge quarry was opened prior to the Consolidated plant, but its output is mostly in the form of poultry grit with only a small amount used as ballast and concrete aggregate.

During the 1930's the Works Progress Administration leased the DeKalb County quarry north of Little Stone Mountain and the Flat Rock quarry north of Stone Mountain. Small crushing plants were built to produce crushed stone for road ballast and concrete aggregate used in the administration's building programs.

At the present time the Davidson Granite Company and the Consolidated Quarry Corporation are the only major producers of the district, but there are several smaller producers who add considerably to the total output. The Kellogg Granite Company, operated by A. B. Kellogg, produces a combined total of 25,000 tons of rubble and 100,000 lineal feet of rough curb stone per year from quarries on the north side of Rock Chapel Mountain and the east side of Stone Mountain. The entire production from these quarries is sold by the Consolidated Quarry Corporation.

The Coffey Granite Company, owned by G. A. Coffey, had an estimated output of 25,000 to 30,000 tons of rubble and 75,000 to 100,000 lineal feet of rough curb stone in 1950 from quarries on the south side of Mile Rock, west of Arabia

Mountain. Other smaller quarries produce a proportionately lesser amount of stone.

The total stone production of the district in 1949 was more than 1,400,000 tons, valued at well over $3,000,000. By comparison, the most productive year noted in Watson's report was 1891 when the value of all the granite and gneiss produced in Georgia was $790,000. The increase in value and production, which has occurred at the same time that market areas have diminished due to greater shipping costs, can be directly related to the development of new markets supplied by the greater plant facilities of the two major producers.

TYPES OF STONE

Stone Mountain Granite (Quartz-Monzonite)

The Stone Mountain granite (quartz-monzonite) is a fine- to medium-grained, almost pure white stone with a faint planar structure or foliation produced by parallel orientation of mica flakes. It is relatively hard, but easily quarried because of its pronounced rift and grain.

The rock has a rather constant composition throughout its areal distribution except for the more biotitic phases in the vicinity of Lithonia. It has an average composition of approximately 30% quartz, 31% oligoclase, 28% microcline, 10% muscovite, 1½% biotite, and traces of other minerals including epidote, garnet, apatite, zircon, pyrite, rutile, sericite, and calcite. In the vicinity of Stone Mountain the rock has slightly more oligoclase than microcline, but near Centerville and Redan the proportions are reversed. A rock of this composition falls into the quartz-monzonite category of most igneous rock classifications. For this reason it is reclassified as a quartz-monzonite in this report although the name granite is retained in its broad meaning as a light colored, medium-grained igneous rock.

Viewed from a distance the stone appears homogenous, but close inspection reveals a quite noticeable foliation due to a small amount of biotite mixed with muscovite. The foliation is made more pronounced in some parts of the exposure by the presence of mica patches or autoliths flattened in the plane of foliation (Fig. 33). Small tourmaline clusters in the rock on the east and south sides of Stone Mountain give it a spotted appearance locally (Fig. 37).

Lithonia Gneiss

The Lithonia gneiss is a very hard gray-white stone with a pronounced highly deformed and sheared banding. The individual bands are composed of white quartz and feldspar layers alternating with thin biotite-rich layers. The gneiss is well suited for general building purposes and street curbing because of its ease of quarrying and ability to withstand weathering. Locally the stone contains an objectionable amount of pyrite which readily changes to limonite, staining the rock with brown streaks.

The composition of the gneiss is quite variable because of the numerous biotite-rich, garnet-epidote, and quartz-rich layers in many exposures. In addition, many quartz and aplite veins and granite and pegmatite dikes intimately intrude the gneiss. Typical mineral compositions of several of the rock types are given in Table 1.

Texturally the rock is xenoblastic (grains are without crystal shape) and slightly inequigranular. Grain boundaries are irregular and frequently serrate or "saw-toothed" and replacement textures are common.

The structures of the gneiss most commonly referred to in the section on description of quarries are banding, contortions or flow folds, shear zones, biotite orientation or lineation, rift and grain. The banding has been described above, but perhaps the other terms need some explanation. The contortions or flow folds are small flexures of the banding which have a small amplitude, usually no more than one foot in height. These flexures are frequently accompanied by shear zones which occur as small healed breaks across the banding, commonly filled with white aplite veins. In the quarries, the majority of the shear zones trend in a north northeast direction and a minority trend in a northwesterly direction. The biotite lineation is a stretching of individual biotite flakes in a northwest-southeast direction and can best be seen in stone which has been split parallel to the banding. The rift of the stone is the easiest direction of splitting and is parallel to the surface. Natural rift planes are known as sheeting planes. The grain of the stone is the second easiest direction of splitting and is always perpendicular to the rift, but it trends in a different direction in every quarry.

Panola Granite

The Panola granite is a mass of igneous rock of limited areal extent located near the southeastern corner of DeKalb County. It forms a small prominence south of Panola known as Hog Mountain. The rock is unlike the Stone Mountain granite or the Lithonia gneiss in structure, texture and composition. It shows no visible structure but has a pronounced porphyritic texture formed by small phenocrysts (crystals) of microcline. A sample of the rock taken from the Bowers quarry at Panola showed a large number of thin epidote veins filling the fractures. Under the microscope the individual minerals are almost equigranular except for occasional large microcline phenocrysts. The mineral composition of the rock, in order of abundance, is microcline, quartz, oligoclase (plagioclase), and biotite with accessory amounts of muscovite, epidote, apatite, magnetite, rutile, and chlorite. The quartz is strained and the microcline is highly altered to muscovite and sericite. The biotite is slightly altered to chlorite.

Because so little of this stone has been quarried, its qualities as a building stone are not known. The stone at the Bowers quarry is contaminated by many epidote veins but surface examination of the larger mass at Hog Mountain indicates that they are scarce or absent there. As far as the writer knows, no physical tests have been made on the stone to determine its durability.

PHYSICAL CHARACTERISTICS OF GRANITE AND GNEISS

General Statement

The physical characteristics of granite and gneiss include hardness, crushing strength, structure, texture, mineral composition and color. The combination of these characteristics determines the desirability and the economic value of the stone. Although they were described thoroughly by Watson (1902), some additional information will be given here.

Hardness

The hardness of a rock is a measure of its ability to withstand abrasion and is dependent on its internal constitution. The hardness of a mineral is determined by the atomic structure and type of atoms or molecules making up the structure, whereas the hardness of a rock is determined by the type and arrangement of the constituent minerals.

Most granites and gneisses are very hard because the two main constituents, quartz and feldspar, are hard. The hardness of these rocks is further increased by the tightly interlocking texture of the mineral grains.

The hardness decreases with the age of the stone because of the weathering agencies of oxidation, carbonation, and hydration. The minerals most susceptible to weathering are the feldspars, orthoclase (or microcline) and plagioclase, which alter to clay. This alteration loosens the interlocking texture and causes the stone to crumble in the most advanced stages of decay.

Crushing Strength

Crushing strength tests made on Lithonia gneiss and Stone Mountain granite at the Washington Navy Yard in 1887 (Watson, 1902, p. 54) showed that the former rock type had a range in strength from approximately 13,000 to over 21,000 pounds per square inch, and Stone Mountain granite had a range from approximately 12,000 to over 21,000 pounds per square inch. These values are well above the maximum strength required of stone used for structural purposes.

Structure

Each of the three building stones of the district has a different structure. The Lithonia gneiss has a pronounced banding which is strongly contorted and sheared. The Stone Mountain granite has a weak to strong foliation or flow structure, and the Panola granite is essentially devoid of any structure. These structures have no apparent effect on the durability of the stone since none of the rocks will break parallel to the structures more readily than across them, nor do they weather (decompose) more easily in one direction than another.

The structure of the rock, especially the Lithonia gneiss, does effect the economic value of the stone. The numerous pegmatite dikes and veins, the quartz veins, and the pink garnetiferous layers all effect the quarrying operations because these portions of the rock cannot be used. In addition, the stone does not break properly across these features. The pegmatite dikes in the Stone Mountain granite have the same effect, although they are not so objectionable since they are not so numerous.

Texture

The textures of the building stones of the district are similar, in that the mineral grains composing the stones are tightly interlocked, forming very compact and strong bonds. It is this texture which helps give the rocks a high crushing strength and hence makes them very suitable for structural purposes.

Mineral Composition

The minerals composing the several rock types are essentially the same. Each type contains quartz, oligoclase, microcline, biotite, muscovite and accessory amounts of garnet, epidote, magnetite, zircon, etc., but in slightly different proportions.

Color

The color of the building stones of the district depends on the mineral composition mentioned above. If it were not for the minor constituents, the rocks would all be white because quartz, oligoclase, and microcline are white or colorless. However, in the case of the Lithonia gneiss the chief accessory, biotite, forms about 3 percent by volume of the rock, and this is concentrated in thin bands giving the rock a gray-white appearance. The Panola granite also contains about 3 percent of biotite, but it is scattered throughout the rock, giving it a gray color. The Stone Mountain granite, on the other hand, has about 9 percent muscovite and only about 1 percent biotite, giving the rock a very faint gray color.

An important color consideration, although not directly related to the original color of the rock, is the presence of minor amounts of easily oxidized iron bearing minerals. The chief of these is pyrite, an iron sulfide, which tends to decompose readily to limonite, an iron oxide. If this mineral occurs in sufficient amounts, as it does in portions of the Lithonia gneiss, it renders the stone useless or of lesser economic value. This feature can be seen in some of the quarries where large areas of the surface are badly iron-stained.

QUARRYING METHODS

Building Stone

The demand for any particular type of building stone depends upon its beauty, durability, and price. Inasmuch as the building stones of this district fulfill the requirements of beauty and durability, the price, which depends on quarrying and shipping costs, becomes the most important factor.

Rough building stone can be produced and sold in the vicinity of Atlanta at a cost comparable to the cost of brick because of the ease of quarrying. Quarrying is inexpensive because layers of desired thickness can be "raised". This property depends on the natural ability of the rock to split along rift planes parallel to the surface.

The method of raising ledges was discovered early in the history of the district. The process is begun by drilling a hole in the rock to a depth equal to the thickness of the desired ledge. A small charge of blasting powder is placed in the bottom of the hole; and, after filling the hole with clay, the charge is set off. Successively larger charges are set off in the hole over a period of six months, and finally the hole is cleared out in preparation for forcing compressed air into the opening. The last step in the process is usually withheld until a very hot day when the pressure of the air plus the differential expansion of the rock cause the rock to rift over a large surface area.

Quarrying is started at the place where the rift plane intersects the surface, or "runs out" as the quarryman puts it. The quarry face becomes progressively higher as quarrying proceeds because of the slightly wedge-shaped cross section of the raised ledge.

Before quarrying can begin, the direction of easiest breaking of the rock, the grain or run, must be determined. This direction may be known if the exposure has already been quarried; or, in the case of a new exposure, the direction can be determined by trial and error or by noting the most prominent jointing direction.

Rough stone such as rubble and curbing, which requires a minimum of plant and equipment, is produced by many small operators who hire only a few men to work the stone with jack hammers, plug drills, mallets and wedges. Larger blocks such as jetty and dimension stone are produced only by the large companies because they require much heavier equipment such as large air compressors, trucks, hoists, and a plant to finish the stone.

Crushed Stone

The production of crushed stone requires a much larger plant, and in general, a larger exposure of rock than building stone because a small margin of profit makes necessary a large volume of output. Although there are only two commercial crushed stone producers in the district, the total value of their output in 1949 was over $2,000,000. This is compared with the total value of the stone of the district which slightly exceeded $3,000,000.

The Davidson Granite Company quarries stone from the Big Ledge quarry for the production of poultry grit and concrete aggregate. The operation begins with the drilling of large holes about ten feet back from the face of the opening with two wagon drills. The holes are drilled as deep as the face is high and then filled with dynamite. After the face is blasted down, the smaller fragments of rock are loaded into Euclid trucks and taken to the initial jaw crusher. The larger blocks of stone are broken into smaller pieces by means of steel balls dropped from derricks.

The Consolidated Quarry Corporation's number one quarry has a 120 foot northern face which is drilled by three 6½ inch churn drills. The face is blasted down and the smaller fragments hauled to the initial jaw crusher by six 12 yard side-dump trucks pulled by Mack chain drive cabs. The larger blocks are broken by placing a small explosive charge in holes drilled by jack hammers.

USES OF STONE

In the early history of the district, prior to and even after

1900, the stone was used mainly for curbing, Belgian blocks, and rubble, and a minor amount was used for monumental and dimension stone purposes. The Belgian blocks and curb stones were transported great distances by rail to be used in St. Louis, Missouri, Baltimore, Maryland, and other large cities. As labor and transportation costs increased, the stone was shipped shorter distances; and with the advent of the automobile and Macadam and asphalt paved highways, the use of Belgian blocks declined and finally ceased. The Stone Mountain granite was found after a time to be poorly suited for monumental stone and its production finally ceased.

Other uses were found to take the place of those that diminished. Crushed stone became an important product, and production of dimensional stock increased as the Davidson Granite Company's Pine Mountain plant increased in size. Most of the crushed stone was used for road ballast and concrete aggregate at first, but poultry grit soon became a major outlet. Later, the building of jetties in some southern cities such as Jacksonville, Florida, and New Orleans, Louisiana, opened a new market for the stone. At the present time the Davidson Granite Company produces a combined total of 15,000 tons of rubble and jetty stone, and the Consolidated Quarry Corporation produces 50,000 tons of jetty stone.

New uses for the stone are continually being investigated by the large stone producers. The Consolidated Quarry Corporation is investigating such uses as washed sand for concrete bricks and feldspar for glass, pottery and enamels. Eventually the potash and rare elements may be utilized as fertilizer supplements.

DESCRIPTION OF QUARRIES

GENERAL STATEMENT

The locations of the quarries described below are shown on the quarry map of the district (Plate 8, in pocket) for quick reference. The distances given in the text are only approximate and can be more accurately measured from the map.

The names of many of the quarries do not conform to those of the Watson report (1902) because of change in ownership.

In some instances the former name is given in the quarry description.

STONE MOUNTAIN GRANITE (QUARTZ-MONZONITE)

DeKalb County

Block Quarry—Two rather small quarries in Stone Mountain granite, located about three and a half miles southeast of the village of Stone Mountain, are owned by Mr. Bates Block of Atlanta. The larger of the two quarries is only a few hundred feet east of the Wade residence. The smaller one is in a flat-rock exposure about five acres in area, several hundred yards south of the large quarry near the headwaters of Crooked Creek.

The rock is gray-white granite remarkably free from blemishes or inclusions. It contains about twice as much muscovite as brownish biotite. Structures are not pronounced in the rock, but a faint flowage foliation trends N5°W and dips 40°E. A strong set of joints strikes N35°W and dips vertically.

Britt Quarry—Mr. Mark Britt of Stone Mountain owns a large quarry two hundred and fifty feet square and up to forty feet deep, located one and one-half miles east of Stone Mountain. It was formerly owned and worked by G. Weiblen and Sons from 1935 to 1946. It was known as the Nash and McCurdy quarry in the Watson report (1902). At present the opening is filled with water.

The rock is typical muscovite-rich granite with a small amount of brown biotite and small pink garnets. On the northwest side of the quarry there are numerous muscovite-rich bands and pegmatites within the granite. A large pegmatite at the north end of the pond has an irregular shape with many projecting tongues or fingers. The rock is highly fractured here and many of the horizontal joints contain yellow uranophane.

A pronounced flowage foliation strikes about N60°W and dips either north or south on the northwest side of the quarry, and strikes about N50°W and dips 35°NE on the east side of the quarry. Locally the foliation is erratic. Joints are not common but a small fault trending N40°W limits the north end of the quarry.

The rock is of good quality for general purposes except for the numerous pegmatite and highly micaceous areas. Further work would be hampered, however, by the large amount of water in the opening.

Coffey Quarries—Mr. G. Coffey owns about five acres of exposed rock about two and one-half miles north northwest of Lithonia. Three quarry openings have been made, the largest of which has a worked face one hundred feet long and three feet high.

The rock is a strongly foliated biotite-rich granite of the Stone Mountain type. It is uniform in texture and composition except for thin muscovite-rich lenses with scattered garnets similar to those found at Stone Mountain. Several coarse-grained pegmatites composed of microcline, quartz, muscovite and biotite have intruded the rock.

The flowage foliation varies in strike from N10°W to N25°W and dips from 15° to 25°W. Joints are very rare. The grain of the rock trends N-S.

Edwards Quarry—A very small quarry on the south slope of Swift Creek, three miles north of Lithonia, is owned by Mrs. I. G. Edwards.

The rock is a medium-grained and evenly textured biotite-rich muscovite granite. Scattered, small, biotite-rich, ellipsoidal inclusions are found throughout the exposure. A pronounced flowage foliation strikes N40°W and dips 10°NE. A set of joints strikes N35°E and dips vertically.

The rock shows pronounced signs of decay, mainly in the kaolinization of the feldspars.

Ethel Quarry—The Ethel quarry is located on a ten acre pavement of granite three miles east of the village of Stone Mountain. The quarry face is two hundred feet long in a northeasterly direction.

Small, disseminated pink garnets are found throughout the rock which is distinctly foliated biotite-bearing muscovite granite. Small, zoned aplite dikes have medium-grained muscovite borders and fine-grained white aplite centers. Irregular pegmatite pods contain small black tourmaline rosettes. Light green damourite occurs on several small slickensided faults.

Flat Rock Quarry—The Flat Rock Quarry is owned by Mr. W. H. Venable of Stone Mountain. It is located approximately one-half mile north of the carving on Stone Mountain.

There are two quarries on the property, a large one on the north (Fig. 40), and a smaller one on the south. The rock in both openings is a medium-grained muscovite granite with small pink garnets scattered throughout. A faint flowage foliation trends approximately N45°W and varies in dip from 10° to 40°NE. Several steeply dipping faults on the northwest side of the opening are coated with light green damourite.

In the vicinity of the faults tourmaline clusters are abundant, and on the southwest side of the quarry numerous garnet-bearing muscovite inclusions are common. A yellow-green coating of uranophane is found on many of the horizontal sheeting planes.

The quarry and a small crushing plant now in disuse were

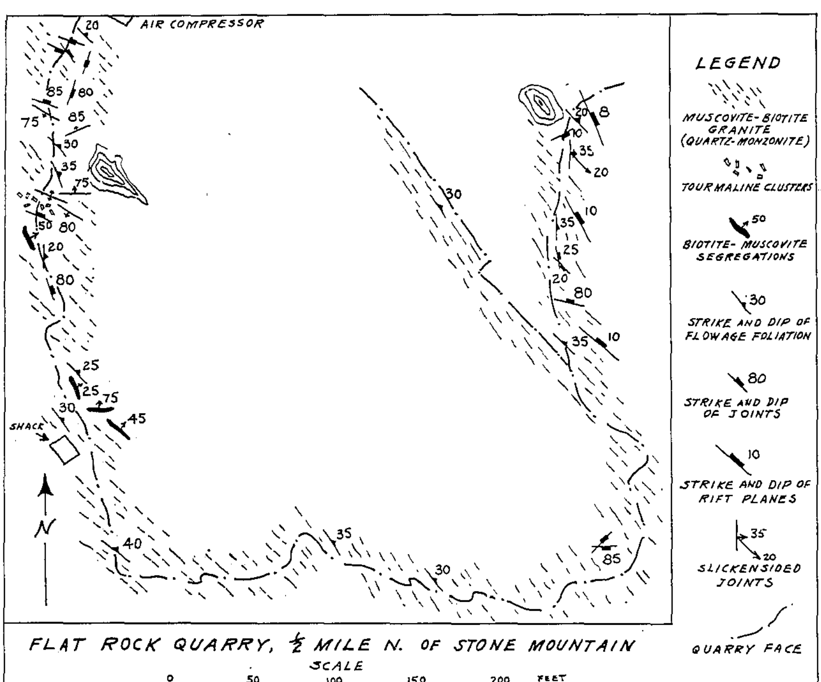


Fig. 40

operated during the period from 1935 to 1940 by the Works Progress Administration for crushed stone. It is now operated by Mr. Venable for rubble.

Kellogg Quarry—A large quarry on the east side of Stone Mountain is leased by Arthur Kellogg from the Venable Brothers estate and operated by Otis King. The quarry has been in continuous operation since 1947. It was previously operated by the Stone Mountain Granite Corporation (Weiblen and Sons) from 1916 to 1934, and by the Works Progress Administration from 1935 to 1940.

In 1950 the quarry production was 1200 tons of stone per week, divided into 700 tons of rough curb stone and 500 tons of rubble. Due to the high cost of shipping, the stone is used almost exclusively in the greater Atlanta area.

The stone is good quality biotite-bearing muscovite granite. The mineral composition is given in Table 5, sample number S68. The only flaws in the rock are numerous small tourmaline clusters, and occasional pegmatite dikes and biotite gneiss inclusions (fig. 35). Small ellipsoidal, garnet-bearing, muscovite-biotite inclusions are found in the rock, oriented parallel to the flowage foliation, which ranges in strike from N20° to N50°E and ranges in dip from 30° to 50°SE. The grain of the rock trends about N35°W in this locality. Rare blue lazulite grains are found in the south ledge of the quarry.

Robertson Quarry—A very small quarry owned by James Robertson is located about four miles southwest of Lithonia and two-thirds of a mile west of Pole Bridge Creek. It is in a large pavement at the crest of a hill trending roughly east-west.

The rock is a medium-grained, well foliated, biotite-rich granite. Biotite comprises about two-thirds of the mica but on the weathered surface the muscovite plus bleached biotite give the rock the appearance of typical Stone Mountain granite. The foliation is nearly horizontal.

The rock has been only slightly quarried, apparently for local use.

Sexton Quarry—The stone of the W. E. Sexton quarry, located three miles southeast of Stone Mountain village, is quite variable in character. The rock is muscovite-rich granite with many micaceous inclusions, tourmaline clusters and small irregular stringers of pegmatite.

The rock is not of acceptable grade for any purpose other than crushed stone. The owner worked it for this purpose for a short time but has since discontinued the operation.

Smith Quarry—A small quarry on the Smith property one-half mile north of Redan is owned by the Venable Estate of Stone Mountain. The rock is coarse-grained, non-foliated Stone Mountain granite composed of quartz, oligoclase, microcline, muscovite, biotite and small pink garnets. Many small biotite-rich inclusions are found in the rock.

Only a small amount of stone was quarried from this location. The small size of the exposure and the poor quality of the stone make it undesirable for future quarrying.

Venable Estate Quarries—Two large quarries on the south side of Stone Mountain and several smaller quarries on the west and northwest sides of the mountain were formerly owned and operated by the Venable Brothers of Stone Mountain. They are now the property of their successor, the Venable Estate.

The quarries were operated on a large scale about 1900, but have since been closed and the equipment moved. The track of a spur of the Georgia Railroad has also been removed, and the only remainder of the operations are the stone walls of the finishing buildings in which were produced twenty thousand car loads of combined paving blocks, curb stones, building blocks and monumental stone annually (Watson, 1902, p. 113).

The rock is a light-gray biotite-bearing muscovite granite containing occasional pink garnets. Many garnetiferous muscovite-biotite inclusions and tourmaline clusters (Fig. 37) are scattered throughout the rock. Small aplite dikes with radiating tourmaline crystals are numerous in the easternmost quarry. Greenish mica (mariposite?) is associated with the tourmaline in some of the dikes. Figure 32 is a map of one of the quarries on the northwest side of the mountain.

Wells Quarry—A quarry owned by Steven Wells, located a mile and a quarter north of Redan, is situated in fine-grained, evenly textured Stone Mountain granite. It is a light gray rock composed of microcline, quartz, oligoclase, muscovite, biotite, and minor amounts of epidote, zircon, and garnet (Table 5, no. L58).

A faint foliation in the rock is barely discernible. Small quartz veins cut the granite in various directions in the quarry. The rock is very good quality, hard, and free from blemishes. It was originally quarried to build the DeKalb County Court House in Decatur.

Gwinnett County

Campbell Property—A ledge has been raised but no quarrying has been done on a several acre pavement of Stone Mountain granite located approximately three quarters of a mile east of Centerville. The property is owned by Mr. C. M. Campbell.

The rock is good quality biotite-bearing muscovite granite similar to that at Stone Mountain except that it contains a slightly greater proportion of microcline than oligoclase. A faint flowage foliation strikes N55°W and dips 20°NE. Jointing is not pronounced. Close inspection of the outcrop revealed no blemishes other than a few mica-rich areas. In spite of its good quality the prospects for successful quarrying are unfavorable because of its distance from paved highways and its small areal extent.

PANOLA GRANITE

DeKalb County

Bowers Quarry—A small quarry located on the east side of Georgia Route 155 and south of Yellow River at Panola is owned by Mr. Lincoln Bowers.

The stone is a coarse-grained, porphyritic biotite granite with microcline and biotite phenocrysts up to one-eighth of an inch in diameter. A small amount of magnetite is scattered throughout the rock. The stone is poor quality for quarrying because of the many fractures filled with epidote and chlorite.

Rockdale County

Hog Mountain Property—Hog Mountain is a large dome-shaped prominence of Panola granite similar to that at the Bowers quarry. The property, owned by Mr. John Yarborough of Atlanta, consists of about 600 acres. A small summer resort has been developed around a dammed lake on the southwest side of the mountain.

LITHONIA GNEISS

DeKalb County

Brand Quarries—The J. T. Brand quarries include about eight openings on a 20 acre exposure of Lithonia gneiss located between Little Stone Mountain and Collinsville Mountain. A large amount of stone was removed from these quarries in the late nineteenth and early twentieth centuries mostly for Belgian blocks and curb stone.

The rock is typical highly contorted Lithonia gneiss with numerous garnet and magnetite crystals disseminated throughout. Shear zones, flow folds, and garnet-rich epidote-bearing layers are common in this exposure.

Chapman Quarry—The Archie Chapman quarry is located about one and one-half miles north of Lithonia, approximately 600 yards east of the Stone Mountain-Lithonia Highway. It contains two openings, the larger of which is 150 feet long, 100 feet wide and up to 15 feet deep.

The rock in the large quarry is a faintly banded, medium-grained, light gray biotite gneiss with numerous porphyroblasts of microcline and magnetite. The banding has a uniform strike of N15°E and ranges in dip from 15°-30°E.

The banding becomes progressively more deformed to the east, until it reaches the stage of typical highly sheared and contorted Lithonia gneiss in the eastern quarry. The trend of the banding in this quarry is very erratic, and the rock contains many randomly oriented pegmatite veins and dikes.

The rock has not been quarried for several years although that of the large quarry is a good quality, hard stone. Its extent is limited, however, by the increased number of pegmatite dikes to the east which make quarrying difficult.

Clack Quarries—A small dome-shaped mass of exposed Lithonia gneiss, known as McDaniel Mountain, is located approximately one mile east of Arabia Mountain and just west of the DeKalb County-Rockdale County line. It is owned by Mrs. Golden Clack.

The stone is typical highly contorted Lithonia gneiss with numerous veins and dikes of pegmatite and aplite. The exposure contains several small abandoned quarries on the western side and a small opening on the eastern side which had been quarried as recently as 1950.

Coffey Quarries—Mr. George A. Coffey of Lithonia owns approximately 50 acres of exposed rock on the south end of Mile Rock, just southwest of Arabia Mountain. He also owns 19 acres south of Bradley Mountain. At the time of the writer's visit in 1950, Mr. Coffey was operating six ledges on the south and southwest sides of Mile Rock and leasing part of his property on a royalty basis to the Reagin Granite Company. Twenty men operating three air compressors, twenty plug drills and two jack hammers produced an estimated 25,000 to 30,000 tons of rubble and 75,000 to 100,000 lineal feet of rough curb stone that year.

The rock is typical Lithonia contorted biotite gneiss with numerous garnet and magnetite crystals. Small, dislocated bands of quartz-rich epidote- and garnet-bearing gneiss with a pronounced pink color are common in an abandoned quarry on the west-central portion of the exposure (Figure 20). Locally the rock contains pyrite which weathers to form a limonitic coating on the surface.

The rock is generally extremely contorted with small aplite and pegmatite dikes and veins filling numerous shear zones which trend approximately N20°E.

The rock is a good quality, hard stone suitable for general building purposes. The extensive raised ledges on the property insure an almost unlimited supply of stone for the future.

Consolidated Quarry Corporation—The Consolidated Quarry Corporation owns and operates the largest quarry in the region, located on Rock Chapel Mountain. The quarry covers an area of fifty acres and has a northern face which is 120 feet high. The company also operates a smaller quarry to the south which is 400 feet long, 150 feet wide, and 45 feet high. In addition to the two quarries, the company owns over 200 acres of exposed rock east of Rock Chapel Mountain.

According to Mr. Nelson Severinghaus, general manager and vice-president of the corporation, 1,000,000 tons of crushed stone, 80,000 tons of washed sand and 50,000 tons of jetty stone were produced in 1949. The jetty stone ranges in size from rip rap (25 to 150 pounds) to large ten ton blocks. Additional stone, produced from quarries on the north side of Rock Chapel Mountain, amounted to 25,000 tons of rubble and 100,000 lineal feet of rough curbing in 1949. These latter quarries are leased and operated by the Kellogg Granite Company and the entire output is sold by the Consolidated Granite Corporation.

A pilot plant was set up in 1950 to produce poultry grit at a price of $0.40 per 80 pound sack. The prices of other products (F. O. B. quarry) in 1950 were as follows:

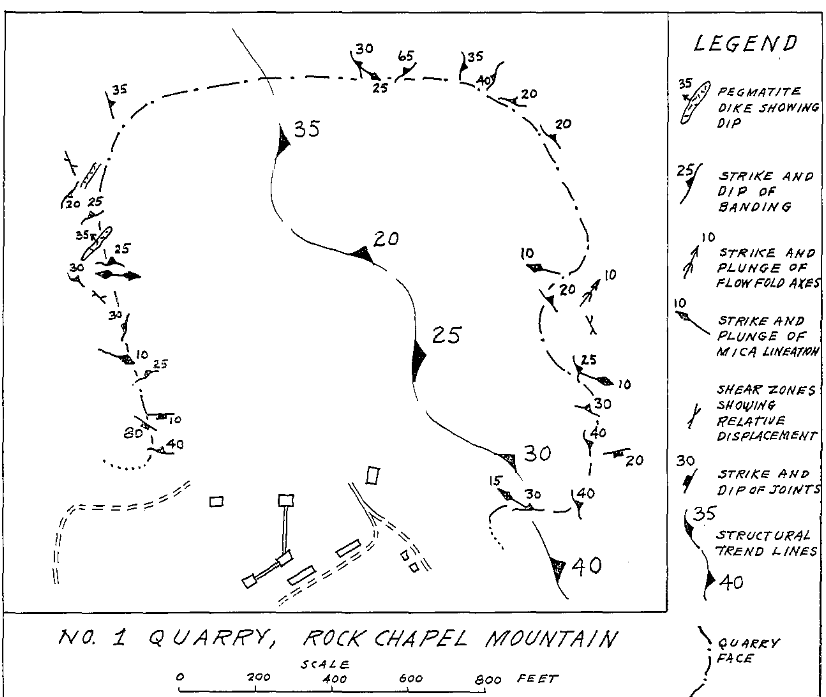


Fig. 41

Rubble	$1.90 per ton
Rough curbing	$0.30 per lineal foot
Crushed stone	$0.60 for undersize fines
	$1.50 for 1/8″ to 3/8″ aggregate

Research is also being undertaken to find other by-product uses for the washed sand which is too fine for concrete aggregate. Among the uses which are being investigated (Severinghaus, 1950, pp. 82-84) are washed sand for concrete bricks, and feldspar for glass, pottery and enamels. The presence of approximately 4.5% potassium oxide (K_2O) and other rare elements may also serve as a supplement to fertilizer in agriculture. The latter use will depend on the solubility of gneiss in the very finely crushed state.

The rock is typical Lithonia gneiss with numerous disseminated garnet and magnetite crystals. The banding is widely variable in attitude (Fig. 41) due to its sheared and contorted nature. Two major sets of shear zones strike N10°-30°E and N50°-70°W. The axes of flow folds (contortions) range in strike from N-S to N20°E and plunge from 10° to 25°N. Perhaps the most striking feature of the large quarry is the presence of numerous, northward dipping, white aplite dikes which can be seen on the east and west faces.

Smaller structural features in the rock include complex, ptygmatically folded quartz veins, garnet- and epidote-bearing bands, and a strong biotite orientation (lineation). Sheeting planes are common in the upper portion of the quarry.

The quarrying operation in the large number one quarry begins with the drilling of 6½″ holes in the north face with three churn drills. After the face is blasted down, the large blocks are drilled with jack hammers and re-blasted to make them small enough for loading by two 4 yard electric shovels. Six 12 yard side-dump trucks are used to haul the stone to the initial 60″ by 48″ Allis Chalmers jaw crusher.

The side-dump trailers (Figure 42), developed by Nelson Severinghaus in the late 1930's were awarded first prize in the Lincoln Arc Welding Foundation design competition (Automotive Trailer Division). The patent, sold to the Easton Car and Construction Company of Easton, Pennsylvania, features an open-sided box-type body which utilizes a hoist independent of the chasis at the dumping point. This independent hoisting increases the life of the trailer by absorbing the total weight of the load.

The flow sheet of the number one quarry and main plant after leaving the initial jaw crusher is as follows:

42″ 270 foot belt to storage

↓

Jeffery Traylor feeder

↓

42″ 150 foot belt

↓

Two 20″ Allis Chalmers gyratory crushers

↓

36″ belt to revolving and vibrating screens

↓

Oversize returned to two 4 foot Symons cone crushers.

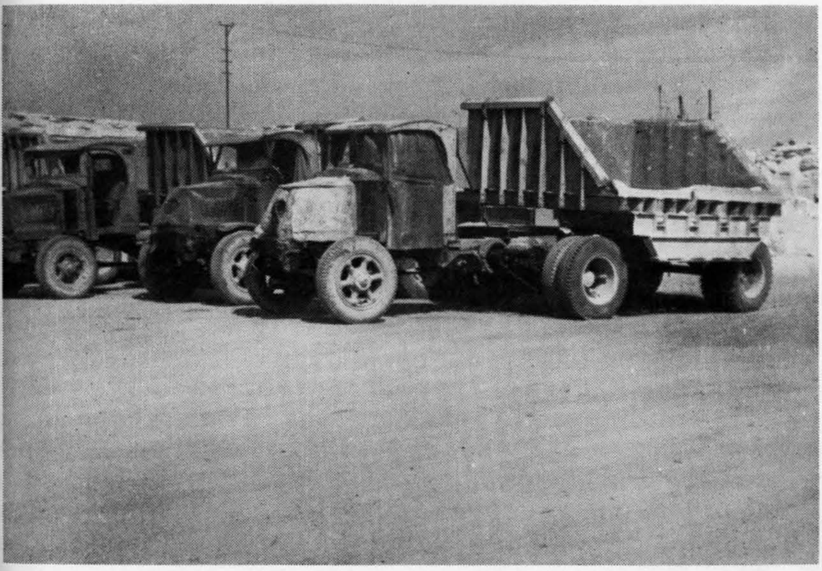


Fig. 42. Side dump trucks used by the Consolidated Quarry Corporation.

The screens separate the stone into seven sizes ranging from one-eighth inch to 2 inches which are stored separately or blended. Part of the one-eighth inch size is sent to a hydraulic and screw classifier sand washing plant for the production of fine aggregate.

The flow sheet of the small number two quarry and plant begins with two wagon drills, three jack hammers, and a two yard P and H diesel shovel. From there it is as follows:

Two Euclid 10 yard trucks

↓

42″ x 10′ pan feeder

↓

30″ x 42″ Pioneer jaw crusher

↓

30″ belt

↓

4′ x 8′ double deck vibrating screen.

Three sizes are screened in the number two plant: oversize, intermediate, and undersize. The oversize goes to a three-foot Traylor T. Y. gyratory crusher and the intermediate size goes to a three foot Symons cone crusher. All three products are mixed and taken to a storage pile by a 24 inch belt. A belt beneath the storage pile feeds the product to the 36 inch belt in the number one plant.

The capacity of the number one plant is 300 tons per hour and that of the number two plant is 100 tons per hour. The size of the operation has increased from an annual production of 150,000 tons in the initial year of 1929 to well over 1,000,000 tons in 1950.

Cooper Quarry—Five acres of exposed Lithonia gneiss located east of the Lon Plunkett quarry and two and one-half miles south of Lithonia are owned by Mr. W. C. Cooper of Lithonia. A small quarry on the property was last worked in 1942 for rubble.

Davidson Granite Company—The Davidson Granite Company of Lithonia owns and operates the Big Ledge and Pine Mountain (Little Stone Mountain) quarries, two of the largest in the area, and owns or leases a large portion of the exposed Lithonia gneiss in the vicinity of Lithonia. This includes the North Georgia quarries (70 acres), the north portion of Mile Rock and a portion of Collinsville Mountain.

The company is owned by N. A., J. K. Jr., and Charles Davidson of Lithonia and operates under the following corporate names:

The Stone Mountain Grit Company

The Davidson Brothers

The Davidson Granite Company

The Davidson Corporation

The Stone Mountain Grit Company produces crushed stone and poultry grit from the Big Ledge quarry, and the Davidson Corporation produces cut and dimension stone, street curbing, rubble and jetty stone from the Pine Mountain quarry.

The large crushing plant located at the Big Ledge quarry completely burned down in the late spring of 1950, and was replaced by a new, modern plant.

Manufacture of crushed stone and poultry grit begins with the drilling of the face of the Big Ledge quarry with two wagon drills, blasting, and breaking of the large blocks with steel balls dropped from derricks. The stone is loaded into Euclid trucks and taken to the initial 42 inch jaw crusher. From this point the stone follows the flow sheet shown below.

Compressed air to operate the pneumatic drills for the Pine Mountain quarry and to operate the pneumatic tools in the large 400-foot finishing shed is provided by compressors in a separate building located on the northwest side of the quarry. The finishing shed houses gang saws, diamond saws, pneumatic surfacers and finishers. A large overhead crane moves blocks of stone from one part of the building to another for surfacing, finishing or sawing. Some of the products of this plant include base courses, bulkheads, steps, copings, straight or circular curb stone and ashlar facings. Rip rap, curbing, jetty stone, rubble, paving blocks and monumental blocks are also manufactured from this quarry.

36″ cone crusher

↓

one to three small cone crushers
(stone should be dry at this point)

↓

screens and return conveyors
(screens vary from 3″ down to 40 mesh sand)

↙ 40-100 mesh sand bins

↘ 30-40% sand waste

↙

series of temporary storage bins

↘ portion returned to screens

↓

permanent storage bins

↙ crushed stone bins

↘ bagging machines

The crushed stone used for poultry grit ranges from one-fourth inch (turkey size) to 40 mesh (canary size).

Production from the Big Ledge quarry (Stone Mountain Grit Company) in 1949 was 150,000 tons of crushed stone of which 100,000 tons was sold as poultry grit and the remaining 50,000 tons was sold as concrete aggregate. Ten thousand tons of cut or dimension stone, 25,000 tons of street curbing and 15,000 tons of combined rubble and jetty stone were produced from the Pine Mountain quarry.

The stone from both major quarries is a good quality, highly contorted Lithonia biotite gneiss. Numerous shear zones and aplite veins as well as larger discordant pegmatite dikes cut the banding. Garnet-rich, epidote-bearing bands are numerous locally, especially in the Pine Mountain quarry. Black magnetite crystals are found throughout the gneiss.

The description of the individual quarries of the company, including detailed structural features, are given below.

Big Ledge Quarry—The Big Ledge quarry, occupying 135 acres, is located about one mile north of Lithonia. The property, which also includes the old Abram and Braswell properties, was formerly owned by the Southern Granite Company. The northern end of the quarry is presently being worked for granite grit, concrete aggregate, road ballast and jetty stone. The south end is being held in reserve for future use as building stone (Figure 43).

The rock is good quality gray-white Lithonia gneiss composed of quartz, microcline, oligoclase, biotite, and minor amounts of muscovite, epidote, magnetite, zircon and apatite. The banding is highly sheared, flow-folded and intruded by irregular biotite granite dikes, pegmatite dikes and aplite veins. The shear zones and flow fold axes trend approxi-

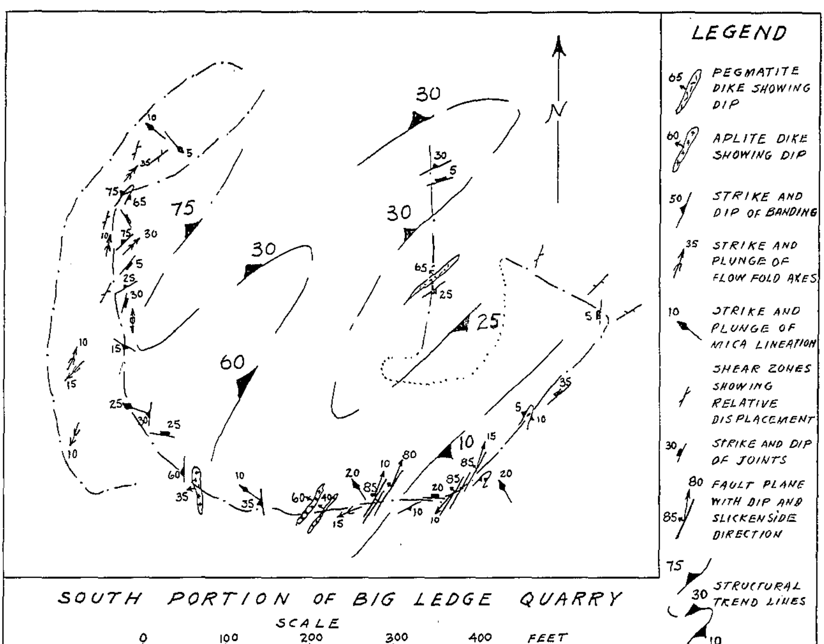


Fig. 43

mately N30°E. Pink garnetiferous layers are occasionally seen.

Pine Mountain Quarry—The Pine Mountain quarry occupies the upper portion of Little Stone Mountain consisting of 380 acres of exposed Lithonia gneiss (Plate 4). Two levels of ledges were being quarried at the time of the writer's visit in 1950; a lower level on the east, southwest and north slopes, and an upper level near the top of the mountain.

The rock is highly contorted, medium-grained Lithonia biotite gneiss. It is very hard, gray-white stone suitable for general building and monumental purposes. The banding is highly variable throughout, but shear zones and mica lineation are regular in trend. A major set of shear zones strike about N20°E and a minor set trends northwesterly (Plate 4). The mica lineation plunges northwest or southeast.

Slightly pink, garnet-rich, epidote-bearing layers parallel to the banding are common in the north and central portions of the quarry (Plate 5, figures 3, 4, 5 and 7). They are often intruded by pegmatite dikes and offset by small faults or shear zones. White aplite and quartz veins tightly infolded with the banding are shown in Plate 5, figures 1 and 6.

The future production from this quarry is almost unlimited due to the large size of the exposure and its easy accessibility. The company transports the stone from its quarry and finishing shed to the main line of the Georgia Railroad by its own spur line railroad.

Arabia Mountain and Bradley Mountain Quarries—Arabia Mountain is a large knob of Lithonia gneiss covering an area of 205 acres, located two and one-half miles south of Lithonia. Bradley Mountain is located just southwest of Arabia Mountain.

Arabia Mountain was quarried extensively around 1900 for Belgian blocks, street curbing, and building stone. Quarry openings are located on the east, west and southwest sides of the peak.

The gneiss is high in magnetite on the east side of Arabia Mountain where it also contains many small pegmatite pods with biotite-rich borders. Small discordant dikes of biotite granite cutting across the banding can be seen in several quarry faces. The banding is highly deformed and sheared on the east side of the mountain. Two sets of shear zones trend N35°E and N85°E, respectively. Many of the shear zones are filled with aplite or pegmatite veins. Garnet- and epidote-bearing bands are found in several parts of the quarry.

None of the former production facilities for the operation remain except the old road bed for a spur line of the Georgia Railroad. However, quarrying could easily be resumed because of the many raised ledges on both mountains.

North Georgia Quarries—The North Georgia quarries are located about one mile west of Rock Chapel Mountain on the west side of Swift Creek. At least five separate quarry openings are located on the exposure covering an area of approximately seventy acres.

The rock is typical, highly contorted and sheared Lithonia biotite gneiss. The banding shows no regularity, but biotite flakes are strongly oriented in a northwest-southeast direction. Garnet and magnetite crystals are common.

In several quarries to the southwest of the main exposure, the rock is more highly pegmatized and intruded by homogeneous granite and aplite. In many places the banding grades gradually into a medium-grained, structureless, biotite granite.

This property provides an excellent reserve of good quality rock for use as building stone or aggregate. The quarries were formerly owned by Messrs. Watson and Brantley, and Mrs. Bowe of Lithonia. Under their ownership (Watson, 1902, p. 130) 150 carloads of rock were produced from February to August, 1898.

Davis Quarry—The western portion of Collinsville Mountain, located about two-thirds of a mile south of Little Stone Mountain and just north of Georgia Route 12, is owned by Mr. Will Davis of Lithonia. The property is now leased to the Davidson Brothers.

The rock is strongly contorted gray-white Lithonia gneiss composed of microcline, oligoclase, quartz and biotite with accessory amounts of magnetite, garnet, epidote, and zircon. Numerous shear zones range in strike from N5°-25°E and biotite flakes are stretched in northwest-southeast direction. Axes of small flow folds (contortions) range in strike from N25°-50°E and plunge from 10°-25°N.

Several small garnet-rich layers like those in the Pine Mountain quarry can be seen in the surface of the exposure. Biotite-rich patches parallel to the banding are common. Scolecite, a radiating, fibrous, white zeolite occurs in joint surfaces in this quarry.

DeKalb County Quarry—The DeKalb County quarry is a moderately large opening in Lithonia gneiss located about two-thirds of a mile north of Little Stone Mountain and directly south of an unpaved county road. The property was formerly owned by Mr. J. W. Johnston but is now owned by the county. In 1950 it was leased to Mr. W. F. Beauford who supplied curb stone to the county.

The rock is typical Lithonia gneiss which is highly contorted and sheared. It is similar to that of Little Stone Mountain in the large number of garnet-rich bands parallel to the banding. Rather abundant aplite and pegmatite veins and dikes cut across the banding in a northeasterly direction. Figure 22 is a small map of the quarry showing the general structures of the rock and Plate 6 shows the structures in detail.

Elliot Quarries—A small quarry two and one-half miles northeast of Lithonia is owned by Mr. Coy Elliot. Several small openings are located in a pavement which covers an area of approximately five acres.

The rock is highly contorted Lithonia gneiss with random orientation of banding and abundant shear zones trending N30°-40°E. Magnetite crystals, white aplite veins and areas of homogeneous biotite granite are common features of the quarry. A small fault forming one face of the quarry is coated with greenish damourite, muscovite, black tourmaline and a brownish stain.

Gaines Quarry—The Gaines quarry, owned by Mr. M. A. Gaines of Gaines Lake, is located about one-half mile north of Georgia Route 12 on the west side of a dirt road running approximately along the DeKalb County-Rockdale County line. The largest of several openings is about three feet high. The quarry has not been worked for at least twenty years.

The rock is highly contorted Lithonia gneiss with common magnetite crystals and rare pink garnets. Many small shear zones trend N25°E. The rock is medium-grained and evenly banded with quartz-feldspar bands about one-fourth inch wide.

Hammock Quarry—A small quarry owned by Mr. Harvey Hammock is located approximately one mile north of Little Stone Mountain and 400 yards north of the DeKalb County quarry. It was last quarried about 1943.

The opening is in medium- to coarse-grained, highly contorted Lithonia gneiss. Where consistent in trend, the banding ranges in strike from N35°-60°W and dips from 10°N to vertical. Numerous shear zones in the quarry range in strike from N30°-50°E. Several garnet-epidote layers parallel to the banding are only a few inches wide. Black tourmaline occurs on the surfaces of small faults as tiny matted crystals.

Hayden Quarry—A small quarry in moderately contorted Lithonia gneiss located just north of Forest Lake is owned by the Hayden Estate and leased to Jeff Aycock for the production of rubble and cut stone. Locally, the rock is called Polecat stone.

The gneiss is gray-white, evenly banded and strongly sheared. The banding strikes approximately N10°E and dips 20°-35°W. The axes of numerous small flow folds trend N5°-35°E and plunge 5°-15°N. Shear zones filled with white aplite strike N10°E.

The composition of the rock in the quarry based on one sample is that of a quartz-monzonite (Table 1, no. L6) containing local concentrations of pyrite and red garnet and a moderate amount of magnetite. Aside from the pyrite and garnet areas the rock is of good quality suitable for general building purposes.

Haygood Quarry—A small quarry located about one-half mile northwest of Arabia Lake was formerly owned by Mr. W. O. Smith and is now owned by Mr. M. J. Haygood.

The rock is medium- to coarse-grained, highly contorted

Lithonia gneiss. Numerous small white aplite veins parallel to the banding are twisted into random orientations. Shear zones are abundant with a majority striking N30°E and others striking in various directions between N-S and E-W. The quarry was last worked in 1939 for rubble.

Hutchens Quarry—The H. H. Hutchens property is located about 500 yards northeast of the Hayden quarry. It is a small opening in Lithonia gneiss now covered with black stain and lichens. It has been inactive since about 1900.

Johnson Quarry—A small abandoned quarry located about one mile northwest of Forest Lake is owned by J. C. Johnson of Lithonia. It was last operated around 1900 for stone for a building in Lithonia.

The rock is highly sheared Lithonia gneiss with many small aplite and pegmatite dikes in random orientation. The quarry is now covered with mosses and lichens, and the worked portion is stained gray or brown due to weathering.

Johnston Quarry—A large quarry located one-quarter of a mile northwest of Little Stone Mountain (Plate 4) is owned by Mr. Snell Johnston. The quarry was operated sporadically for curb stone and rubble during 1950.

The rock is gray, medium-grained and highly contorted Lithonia gneiss. In several parts of the exposure the stone contains numerous white, fine-grained aplite veins and coarse-grained pegmatite dikes. Thin quartz veins parallel to the banding are often intricately folded. Numerous shear zones trend in general about N20°E. The axes of small flow folds are usually parallel to the strike of the shear zones, and a pronounced mica lineation trends in a northwest-southeast direction.

In the north central part of the quarry a garnet-rich epidote-bearing layer has been faulted and the fault filled with pegmatite (Plate 5, fig. 2). A large slickensided joint forms the southeast face of the opening.

The gneiss is good quality stone for general building purposes, and the exposure is large enough to be of continuing economic value. The upper surface has been worked to a depth of ten to twenty feet, and the central portion is being worked to still lower levels. In addition to the present quarry, there is an almost unlimited supply of exposed stone to the southeast.

McClendon Quarries—A series of small quarries, just west of Georgia Route 124 and three-quarters of a mile northwest of Rock Chapel Mountain, are owned by H. O. McClendon of Rock Chapel. The exposure covers an area of several acres on the south side of a small stream. The surface of the outcrop contains many large weathering pits like those described under the section on weathering in Part I.

The banding of the gneiss is highly variable in trend in the south portion of the exposure but becomes more consistent in strike as it approaches the contact with mica schist, located several hundred yards to the north. Near the contact, the banding strikes N70°W and dips 30°N. The gneiss contains many shear zones filled with white aplite.

McMayer Quarry—The McMayer quarry consists of several abandoned surface openings in highly contorted Lithonia gneiss located about 500 yards southwest of Collinsville Mountain. The rock was quarried to provide stone for the Broad Street Bridge in Atlanta.

Park Quarry—A small quarry owned by Mrs. Addie Park of Decatur is located approximately four and one-half miles southwest of Lithonia. The rock is faintly banded but well foliated gneiss similar to the Lithonia type. The foliation strikes generally N85°E and dips 30°N. Although not typical contorted Lithonia gneiss, it is slightly sheared and deformed. The shear zones trend N5°W and the axes of small crenulations strike N20°E and plunge 20°N. Many dikes of Stone Mountain muscovite-rich granite and pegmatite cut across the rock, somewhat impairing its value as a building stone.

Plunkett Quarries—A large pavement exposure of Lithonia gneiss, located one-half mile southwest of Forest Lake, is owned by Mr. Lon Plunkett of Lithonia. Several small and large openings have been made in the rock, one of which was quarried as recently as 1950 for rubble.

The rock is contorted Lithonia biotite gneiss with many disseminated garnet and magnetite crystals. It is medium- to coarse-grained and locally has the appearance of porphyritic granite due to the presence of large feldspar crystals within thin pegmatite veins. Abundant shear zones trend approximately N30°E, and biotite lineation ranges in strike from N30°-50°W and plunges 10°-15°NW or SE. Several small faults located in the southwest corner of the largest quarry are filled with green damourite and radiating tourmaline crystals.

Powell Quarries—A 25 acre, slightly dome-shaped mass of Lithonia gneiss located south of Bradley and Arabia Mountain is owned by M. D. Powell of Klondike. One large and five small openings have been worked on various parts of the property. The present working is about 300 feet wide in an east-west direction and three to five feet high.

The rock is highly contorted Lithonia gneiss with many dikes and veins of white aplite filling northerly trending shear zones. In places where the banding is consistent, mainly on the south side of the exposure near the contact with mica schist, the banding strikes about N70°W and ranges in dip from 60°S to 60°N. The number of shear zones and the amount of deformation of the banding also decrease rapidly as the contact is approached.

Garnet-rich, epidote-bearing bands are common in this exposure and are often faulted along the northeasterly trending shear zones. Large, black tourmaline crystals up to six inches long and more than one inch thick are found in some pegmatite dikes. Locally the tourmaline forms radiating clusters within the gneiss.

In 1950 the stone was quarried for rough curbing and rubble. Most of the curbing was used as coping in cemetery lots.

Reagin Quarries—Mr. Grover Reagin of Lithonia owns a large exposure of gneiss southwest of Little Stone Mountain and south of Tom George Creek. The property contains about twelve large quarry openings of which only one was being operated in 1950. Mr. Reagin also owns and periodically operates several small quarries on the south side of Collinsville Mountain, just north of Georgia Route 12. The production is almost entirely rubble.

The rock in both localities is typical contorted Lithonia gneiss containing disseminated garnet and magnetite crystals.

Northeasterly trending shears are often filled with white aplite veins. Numerous joints are coated with colorless radiating scolecite.

Scales Quarries—Mrs. Lula Scales of Lithonia owns a portion of the exposure southwest of Little Stone Mountain on which the Reagin quarries are located. The rock is the same as that of the Reagin property. No quarrying has been done for many years.

Smith Quarries—Several quarry openings located three- quarters of a mile north of Arabia Lake and near the Haygood quarry are owned by Mr. W. C. Smith of Lithonia. Most of the production from the quarries was used locally for chimney stones, foundation stones and steps.

The rock is highly contorted Lithonia biotite gneiss with many flow folds and shear zones. Folded, lens-shaped, biotite-rich inclusions are common in this locality.

Near the northern contact with mica schist, located a few hundred yards north of the quarries, the banding of the gneiss becomes more consistent in attitude, ranging in strike from N40°-70°W and ranging in dip from 15°-35°N. The quarry was last worked in 1940 by Mr. Smith for rubble.

Turner Quarry—A large amount of stone has been removed from the Henry Turner quarry, located two miles east southeast of Lithonia and immediately north of the Georgia Railroad tracks. The quarry was previously owned jointly by Mrs. Mary Reagin and the Georgia Railroad.

The rock is typical contorted Lithonia gneiss, the same as that of Collinsville Mountain just to the west.

Wilson Quarry—The Archie Wilson quarry is a small opening on the west side of the Lithonia-Stone Mountain Highway, one mile north of Lithonia. It is 250 feet long, 150 feet wide and 20 feet deep.

The rock is highly contorted Lithonia gneiss with numerous small pegmatite dikes and veins rich in muscovite. Magnetite is sparsely scattered throughout the gneiss but is concentrated in small aplite veins. These aplite veins commonly fill northeasterly trending shear zones. The banding of the gneiss is highly variable due to the shearing.

Part of the eastern wall of the quarry is bounded by a fault which trends N10°E and dips 75°W. Slickensides on the fault surface strike N20°W and plunge 30°N.

Gwinnett County

Britt Quarry—A small quarry opening, located one and one-half miles south of Snellville and a short distance east of Georgia Route 124, is owned by Mr. W. C. Britt.

The rock is slightly contorted Lithonia biotite gneiss intruded by numerous dikes of Stone Mountain granite and garnetiferous pegmatites. Small garnet and magnetite crystals are common. A pronounced banding ranges in strike from N30° to 70°E and dips steeply to the west. A faint additional foliation consists of an orientation of biotite flakes at an angle to the banding. This secondary structure dips gently to the west.

The rock was quarried only to a small extent because of the restricted area of exposure and the abundance of cross-cutting dikes of pegmatite and granite.

Byrd Quarry—A small quarry owned by Mr. G. T. Byrd is located two and one-half miles north of Loganville on a branch of Bay Creek. The rock is strongly banded, non-contorted Lithonia biotite gneiss with small disseminated magnetite crystals. The stone was used to build the Loganville Methodist Church.

Gwinnett County Quarry—The Gwinnett County quarry is located approximately three miles east of Snellville on the south side of U. S. Highway 78. The opening is about 250 feet long in a north-south direction and 50 feet high.

The rock is light gray, well-banded Lithonia gneiss. Numerous small pink garnets are disseminated throughout the rock but are slightly more concentrated in biotite bands. The banding is consistent in trend varying in strike from N-S to N20°W and ranging in dip from 10° to 20°E. Locally, the banding is tightly deformed into zig-zag recumbent isoclinal folds. Small pegmatite and quartz veins parallel the banding, but larger biotite granite sills grade almost imperceptibly into the gneiss.

The rock was formerly quarried for road ballast and aggregate but the quarry has not been in operation for several years.

Hayes Quarry—The J. W. Hayes quarry, located about three and one-half miles southeast of Lawrenceville, was formerly known as the Turner quarry. About two acres of exposed pavement contain several small workings which were being quarried for rubble at the time of the writer's visit in 1950.

The pavement is composed of strongly foliated gneiss which resembles the Lithonia type except for a high content of muscovite. The rock apparently weathers rapidly inasmuch as the sap cover is two feet thick in places. It is relatively brittle and breaks easily with several blows of the hammer.

Johnson Property—Several small openings have been made in a large pavement on the E. A. Johnson property located east of Georgia Route 124, about one and one-half miles south-southwest of Snellville.

The rock is essentially non-contorted, strongly banded Lithonia gneiss. It has a higher percentage of muscovite than the typical Lithonia gneiss and is much less contorted and sheared. Small magnetite and garnet crystals are scattered throughout, and light green epidote grains occur locally. Numerous Stone Mountain granite dikes cut the gneiss.

The banding has a consistent strike of N25°E and a vertical dip. Clusters of biotite form a pronounced lineation parallel to the strike of the banding.

The stone is good quality for building purposes except for those areas with a high percentage of granite intrusions. The rock was formerly used for local construction.

Johnston Quarries—A large dome-shaped mass of Lithonia gneiss covering an area of more than 10 acres is owned by Snell Johnston. It is located on the east slope of No Business Creek one and three-quarters of a mile south of Snellville.

The banding of the gneiss is generally highly contorted but is locally non-deformed. Hand specimens of the rock show that it is typical Lithonia gneiss with scattered garnet and magnetite crystals. Locally the muscovite content is increased where large dikes of Stone Mountain granite cut the rock.

About six or seven small openings have been worked on the property, but the largest has a face only about four feet high. The large size of the outcrop and the good quality of the stone make the rock suitable for many purposes. However, the quarries in this vicinity are at a disadvantage because of their greater distance from the market than the quarries of Stone Mountain and Lithonia.

Jones Quarry—The C. V. Jones quarry is located one mile west of the center of Lawrenceville just south of Georgia Route 120. Formerly it was owned by Gwinnett County and prior to that it was known as the Lawrenceville quarry. It is several hundred feet wide and about 50 feet high. It is now filled with water.

The stone is non-contorted but strongly lineated Lithonia-type biotite gneiss. Biotite and a small amount of muscovite are streaked into a pronounced lineation which strikes S40°E and plunges 10°S.

The quarry has not been worked since about 1925 when crushed stone and road ballast were produced.

Kelley Quarry—Mr. Hoke O. Kelley of Atlanta owns a small quarry in a pavement exposure on the west side of Bay Creek, three miles north of Loganville. It was formerly known as the McElvany Shoals quarry. The rock was used to build a stone house and stone wall near the quarry.

The rock is strongly banded, non-contorted Lithonia biotite gneiss. The banding strikes N10°E and dips 15°E. Small biotite-bearing pegmatites strike N45°W and locally deform the banding.

McCart Quarry—The McCart quarry is a very small opening in Lithonia gneiss located on the west side of Georgia Route 124, one and one-half miles north northeast of Centerville.

A pronounced banding in the rock has a fairly consistent trend which ranges in strike from N-S to N30°E and dips 20°E. A lineation formed by orientation of biotite clusters plunges gently to the north. Several pegmatite and granite dikes cut across the banding.

McConnell Quarry—A small quarry located one-half mile northwest of the center of Grayson on the west side of Georgia Route 20 is owned by Mr. J. N. McConnell of Grayson.

It was owned and operated prior to 1900 by G. W. Cates who quarried the rock for a railroad trestle.

The rock is an augen gneiss with quartz and feldspar bands drawn into lenticles. The banding strikes N40°E and dips about 15°W. It is a non-contorted phase of the Lithonia gneiss. A portion of the exposure consists of a biotite granite intrusion which contains garnet and epidote.

Moon Quarries—Several small quarry openings on the Raymond Moon property are located south of U. S. Route 78, a mile and three-quarters east of Snellville.

The rock is Lithonia gneiss with a strong, slightly undulatory banding. It is medium-grained and contains small magnetite crystals and rare garnet crystals. Several small granite and pegmatite dikes trend N50°W.

The quarry was last worked many years ago for building stone for the Snellville school. The surface is now covered with mosses and lichens.

Sawyer Quarry—The J. C. Sawyer quarry is located about three-quarters of a mile northwest of the center of Snellville. The small opening is in medium-grained, strongly banded Lithonia biotite gneiss composed of oligoclase, microcline, quartz, biotite, muscovite and small pink garnets. The banding is slightly deformed with small flow folds whose axes strike N10°E and plunge 10°N. Numerous pegmatite veins cut the gneiss.

Woodruff Quarry—Mr. Hoke Woodruff owns a small quarry in a flat rock exposure of Lithonia gneiss, located about one-quarter of a mile north of U. S. Route 78, approximately three miles northwest of Loganville. The property was formerly owned by Mr. T. Langley.

The rock is highly contorted with many flow folds and shear zones. The rock contains scattered grains of magnetite, pink garnets and green epidote.

Yancy Quarry—A small quarry opening with a ledge about one foot high is located one mile northeast of Grayson on the G. J. Yancy property. The stone is slightly sheared and crenulated Lithonia gneiss containing numerous disseminated magnetite crystals.

Rockdale County

Almond Quarry—The Almond quarry is a small opening just west of Tan Yard Branch at the southwest edge of Conyers. It is owned by Mr. Thomas Parker.

The rock is typical contorted and sheared Lithonia gneiss with a badly iron-stained surface. Pink garnets and magnetite crystals are common in the gneiss, and large tourmaline clusters are found in quartz veins. The grain of the rock, shown by a six foot quarry face, trends approximately N-S.

Beadie Property—Several small openings have been made in a pavement of Lithonia gneiss which crops out on both sides of a county road three miles west northwest of Conyers. The property is now owned by Mr. B. Owens of Conyers. The rock is highly contorted Lithonia gneiss with many disseminated magnetite crystals.

Brooks Quarries—The Brooks quarry consists of several openings in a three acre pavement of Lithonia gneiss about two and one-half miles north northwest of Conyers on the south bank of Yellow River. Prior to 1900, it was known as the Pierce quarry but is now owned by Mr. Cotton of Conyers. The stone was last worked about 1895. The rock is similar to that of the Beadie quarry above.

Calloway Quarry—A small quarry on the northwest side of Milstead is owned by the Calloway Mills Company. It is located on the south side of Yellow River, several hundred yards east of the river bridge.

The rock is a slightly contorted phase of the Lithonia gneiss with only occasional flow folds and shear zones. Its structure is hard to detect because of the dark gray or brown weathered surface, but the banding seems to strike N40°W and dip 40°E. Several small pegmatite dikes about six inches wide range in strike from N50° to 80°E.

Farmer Quarry—The Edward Farmer quarry is located six miles north of Conyers, just south of a highway near the county line. The rock is mildly contorted Lithonia gneiss, containing many small white aplite veins which trend N25°E and dip 25°E. Small magnetite grains are disseminated in the gneiss and larger magnetite crystals are found in the aplite veins. Small irregular pegmatite dikes are common.

Johnston Quarry—The Will Johnston quarry, leased by the Haygood Brothers of Lithonia, is located about one mile northwest of Zingara. The pavement exposure contains about ten acres of good quality contorted Lithonia gneiss. The rock is medium-grained but contains occasional microcline porphyroblasts up to two inches in diameter. The biotite is somewhat altered to chlorite. Small pink garnets and magnetite crystals are scattered throughout the rock.

The stone was being quarried for curbing and rubble at the time of the writer's visit in 1950.

Mahoney Quarry—The C. M. Mahoney quarry, located one mile northeast of Milstead, contains about ten acres of exposed Lithonia gneiss. The quarry consists of two small ledges.

The rock is highly contorted and sheared and contains large feldspar crystals which have been elongated into augen. Small aplite and pegmatite dikes commonly cut across the erratic banding. Small oxidized magnetite crystals have stained the surface a yellow-brown.

The quarry was last worked for curb stone about 1900 by Lee Brantley.

Norton Quarry—A large quarry located one mile northwest of Milstead on the west side of Georgia Route 20 is presently owned by Mr. J. E. Norton. During the period between 1900 and 1915, it was operated by Lee Brantley for Belgian blocks and for curb stone used in St. Louis, Missouri. It has been idle since that time.

The rock is highly folded Lithonia gneiss containing scattered magnetite crystals. A strong banding is cut by numerous shear zones which trend N40°W. The grain of the stone trends N70°W.

Pirkle Quarry—The Pirkle quarry is a small opening on the west side of a large pavement of Lithonia gneiss located about one-half mile south of the village of Zingara. The property is owned by Emma Chandler.

The gneiss is medium-grained and well banded with quartz-feldspar layers up to one-quarter of an inch wide. The banding is non-contorted and consistent in strike. Scattered magnetite crystals and epidote grains are common. Occasional shear zones trend N30°E. One small dike of Stone Mountain muscovite granite was seen in the exposure.

Reagin Quarry—A small quarry owned by W. B. Reagin is located one mile north of Milstead. It was worked about 1900 for rubble, chimney stone and foundation stone. The quarried portion is now covered by mosses and lichens.

The rock is a highly contorted Lithonia gneiss with small magnetite grains scattered throughout. Two pronounced sets of shear zones trend N60°W and N80°W, respectively.

Rockdale County Quarry—The Rockdale County quarry is a large opening in Lithonia gneiss located on the east side of Georgia Route 20, one mile north of Milstead. The quarry was operated on a large scale about 1900 by Lee Brantley of Lithonia. The production at that time was primarily curb stone and Belgian blocks for street paving. Presently the quarry is operated by Rockdale County to supply crushed stone for road ballast and concrete aggregate.

The rock is highly sheared and contorted Lithonia gneiss with many small aplite and pegmatite dike intrusions. Locally the surface is badly iron-stained by decomposition of pyrite contained in the rock.

Shaw Quarry—Mr. Park Shaw of Stone Mountain owns a rather large quarry located two miles north of Conyers. The quarry, with a face about fifteen feet high, was extensively worked about 1900, but has been idle since that time. A small building and a broken dam are the only remains of the former operation.

The rock is highly contorted Lithonia gneiss with random banding.

Sims Quarry—A small quarry located two and one-half miles northwest of Conyers is owned by Carl Sims and operated by E. C. Reagin. The present operation started about May, 1950, but was previously operated about 1900. Mr. Reagin employed two men and used an air compressor to quarry building stone at the time of the writer's visit in 1950.

The rock is typical light gray Lithonia gneiss which is highly contorted and sheared. The banding is erratic.

Whittaker Quarry—Mr. Robert Williams owns a small quarry, formerly known as the Whittaker quarry, in a one acre pavement, located one-half mile south of Conyers on the west side of Georgia Route 138. The quarry has been idle long enough to permit a growth of mosses and lichens on the surface. A yellow-stained sap cover extends about four inches down to the fresh rock.

The stone is highly sheared and contorted Lithonia gneiss with small disseminated magnetite crystals. A prominent set of joints with slickensided surfaces trends N50°E and dips 65°NW.

Walton County

Carter Quarry—A small quarry owned by Lee Carter and formerly owned by Steven Brand is located on Flat Rock Creek in Loganville. The exposure is composed of well banded, medium-grained Lithonia gneiss. The opening is now covered with lichens and stain.

Cown Quarry—The Horace Cown quarry is located on the east side of Loganville, just south of U. S. Route 78. The stone is locally contorted Lithonia gneiss with a slight augen structure. It is medium- to coarse-grained and contains numerous magnetite octahedra. The rock was used to build a structure on the property which is now abandoned.

Forrester Quarry—A small surface opening has been made in a large pavement of Lithonia gneiss just south of the junction of two county roads, approximately six miles southwest of Loganville. The opening is one-half mile west of Sandy Rock Creek.

The rock is highly contorted Lithonia augen gneiss with several percent magnetite. Quarrying was done to provide local building stone.

Guthrie Quarry—A small quarry located a short distance west of Little Haynes Creek, and five miles south of Loganville, is owned by Mr. T. L. Guthrie. The rock, highly contorted Lithonia gneiss, was quarried for local use about forty years ago.

McCuller Quarry—Mr. Ewell McCuller owns a small quarry located four and one-half miles south of Loganville. The stone is highly contorted Lithonia gneiss which has been intimately intruded by coarse-grained homogeneous muscovite-biotite granite (Stone Mountain type). Magnetite crystals are rare and no garnets were observed. The biotite is partly chloritized.

The exposure in which the quarry is located is small and the rock is not of good quality. The stone has not been worked for many years.

Rockmore Quarry—The M. L. Rockmore quarry is located just south of U. S. Route 78 in the village of Loganville. The flat rock exposure covers an area of approximately five acres. The stone was quarried to build the Methodist Church of Loganville, plus several other local structures.

The rock is locally contorted, well-banded Lithonia gneiss with a pronounced augen structure in the coarse-grained portions. Small cross-cutting pegmatite dikes are common in this quarry.

Windsor Bridge Quarry—A small quarry located on the west bank of Alcovy River, five miles northeast of Loganville, is owned by Mr. Dennis Still. The rock is non-contorted Lithonia gneiss with a pronounced augen structure. The stone taken from the opening was used to build the bridge across the Alcovy River.

Yancy Quarry—A small quarry near the northwest limits of Loganville, just north of Georgia Route 20, is owned by Mr. T. D. Yancy. The rock is evenly banded, medium-grained Lithonia-type gneiss. The banding strikes N15°W and dips 25°E. A pronounced mica lineation strikes N10°W and plunges several degrees north.

The rock was quarried many years ago to build a dam across a small stream which runs across the north side of the exposure. The property was formerly known as the Braswell quarry.

GLOSSARY*

ALLOTRIOMORPHIC—Minerals of an igneous rock which show no crystal faces.

ALLUVIUM—River deposited sands.

AMPHIBOLITE—A metamorphic rock consisting essentially of amphibole (usually hornblende) and plagioclase with accessory amounts of epidote, pyroxene, quartz, titanite, etc.

AMPHIBOLITE FACIES—The metamorphic grade in which rocks of appropriate chemical composition contain hornblende and anorthite-bearing plagioclase.

ANTICLINE—An up-arched fold.

ANTITHETIC SHEAR—Shear or fault which forms at a high angle to the relative direction of movement.

APLITE—Light-colored (usually white), sugary-grained igneous vein or dike rock composed essentially of feldspar and quartz.

ARGILLACEOUS—An adjective applied to rocks containing clay.

ATTENUATED—Thinned or tapered.

AUGEN—Eye-shaped mineral grains or aggregates found in some gneisses.

AUTOLITH—A fragment of igneous rock incorporated in an igneous rock of later formation, both of which are considered to be formed from the same parent magma.

BANDING—Alternation of layers of differing mineral composition or texture or both.

BIAXIAL—Containing two optic axes.

BIPYRAMID—A double-ended pyramid.

CHLORITIZATION—Alteration of dark silicates (micas, hornblendes, pyroxenes, etc.) to chlorite.

COLLUVIUM—Heterogeneous rock detritus transported by the action of gravity.

CONFORMABLE—Parallel arrangement of strata or banding.

CONGLOMERATE—Rock composed of rounded pebbles of other rock, cemented together.

CONTORTED—Intricately twisted or folded.

CROSS JOINTS—Joints or breaks which are nearly perpendicular to some linear structure such as a fold axis.

DENDRITIC—Branching as the limbs of a tree.

DIABASE—A dark green to black dike-forming igneous rock mainly composed of randomly oriented plagioclase laths in a matrix of augite. In the Stone Mountain district the rock is fine-grained.

DISCORDANT—Adjective used to describe an igneous intrusion which cuts across bedding or schistosity planes.

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*Many of the definitions are adapted from Rice, C. M., *Dictionary of Geological Terms*, Edwards Bros., Ann Arbor, Mich., 1948.

DISPERSION—The separation of complex light into its different colored rays, as by a prism.

DRAG FOLDS—Minor folds produced by movement of strata past one another during folding.

ELLIPSOID—A surface whose plane sections are all ellipses or circles.

EQUIGRANULAR—Minerals in a rock which are all of essentially the same size.

EUHEDRAL—Textural term applied to minerals with well developed crystal faces.

FABRIC—The shape and arrangement of the constituents of a rock.

FISSURE—An extensive crack or break in rock.

FLOWAGE FOLIATION—A planar structure produced by the subparallel orientation of minerals or groups of minerals by flowage.

FLOW FOLDS—Small folds produced by deformation of a plastic or semi-plastic material.

FOLD AXIS—The invisible line about which starta are bent to form a fold.

FOLIATION—Segregation of particular minerals of a rock into lenses, streaks or individual bands.

GARNETIFEROUS—Containing garnets.

GNEISS—A metamorphic rock with a pronounced banded structure.

GRAIN—A quarrying term meaning the second easiest direction of splitting of a rock.

GRANITE—A medium- to coarse-grained igneous rock composed of potash feldspar, quartz and lesser amount of sodic plagioclase, biotite, muscovite or other dark silicate. In this report the term granite is also applied to igneous rocks of quartz-monzonite composition.

GRANITIZATION—The conversion of solid rocks to rocks of granitic character without passing through a magmatic stage.

GRANOBLASTIC—Sugary-grained (metamorphic texture).

GROUNDMASS—Relatively fine, crystalline portions of a rock contrasted with larger grains such as phenocrysts or porphyroblasts.

IDIOMORPHIC—Mineral grains showing their own crystal faces. Similar to euhedral.

IGNEOUS—Solidification from the molten state.

INCIPIENT—Beginning to show itself.

INDEX MINERAL—A mineral which must be present in metamorphic rocks of certain composition to satisfy the prevailing pressure-temperature conditions.

INDEX OF REFRACTION—A number expressing the ratio of the sine of the angle of incidence: sine of the angle of refraction.

INTERSTRATIFIED—Alternating strata.

ISOCLINAL—A fold whose limbs are parallel.

JOINT—A crack separating two parts of a once continuous block.

KAOLIN—A white, or slightly stained, clay mineral formed by the decomposition of feldspars.

KYANITE ZONE—Metamorphic zone in which kyanite is the index mineral.

LACCOLITE—Same as laccolith. An igneous rock which spreads out laterally between strata like a huge lens.

LENGTH FAST—Long direction of a mineral parallel to the smaller index of refraction of the mineral.

LENGTH SLOW—Long direction of a mineral parallel to the larger index of refraction of the mineral.

LINEATION—Any linear element in a rock such as an elongate mineral, fold axis, etc.

LONGITUDINAL FOLDS—Folds parallel to the major axis of uplift or folding.

MANTLE—Residual cover or weathered rock over unweathered bedrock.

MARBLE—Coarse-grained, recrystallized limestone.

MATRIX—Same as groundmass.

MEGASCOPIC—Seen with the naked eye.

MELADIORITE—Rock with a greater abundance of dark constituents than a normal diorite.

METAMORPHIC FACIES—A rock which has reached certain temperature and pressure conditions will develop a distinct set of minerals dependent upon the chemical composition of the rock.

METAMORPHIC GRADE—Similar to metamorphic facies.

METAMORPHIC ROCKS—Igneous and sedimentary rocks which have been recrystallized by temperature and pressure.

METASOMATISM—Replacement.

MICA FLUCTUATION—Orientation of mica flakes about an axis.

MIGMATITE—Mixed rock composed of an older schist or gneiss with numerous granite or aplite veins parallel to the foliation.

MONADNOCK—Unweathered prominence which rises above the surrounding plain.

OCHRE—Mixture of brown and red iron oxides.

OROGENY—Process of mountain building.

OX BOW LAKE—A crescent-shaped lake formed in an abandoned river bend.

PARAGENESIS—Sequence of formation of minerals in a rock.

PAVEMENT—Nearly flat, unweathered rock mass supporting little or no vegetation.

PEGMATITE—Coarse-grained dike rock composed of potash feldspar, quartz, mica and minor amounts of soda feldspar.

PENEPLAIN—A land surface of slight relief worn down by erosion almost to a plain.

PETROFABRICS—Internal structure of rocks in relation to the movements involved in their formation.

PETROGRAPHY—Systematic field and microscopic description of rocks.

PHENOCRYST—Individual crystal imbedded in a finer-grained groundmass of an igneous rock.

PLANIMETRIC MAP—Map without topographic contours.

PLEOCHROIC—Exhibiting several different colors when looked through in different directions.

PLICATION—A fold.

PLUTON—Irregularly-shaped igneous intrusion.

POIKILITIC—Small grains or crystals enclosed in larger grains of an igneous rock.

POIKILOBLASTIC—Small grains enclosed in larger grains of a metamorphic rock.

POLYHEDRAL—Having many sides.

POLYSYNTHETIC TWINNING—Repeated twinning in which the crystal is made up of thin lamellae alternately in reversed position.

PORPHYRITIC—Igneous rock texture in which larger grains or crystals are enclosed in a finer-grained groundmass.

PORPHYROBLAST—Large crystal which has grown in a rock by metamorphic processes.

PORPHYROBLASTIC—Texture due to the presence of porphyroblasts.

PRISM—An open form of similar faces parallel to the vertical crystallographic axis.

PTYGMATIC—Complexly folded vein or band.

QUARTZ-MONZONITE—A medium- to coarse-grained igneous rock composed of almost equal amounts of potash and soda feldspar, quartz, and lesser amounts of biotite, muscovite, hornblende and other accessory minerals.

QUARTZITE—Recrystallized sandstone composed mainly of quartz.

RELIC—Remnant of an original rock preserved in a rock that has been recrystallized by metamorphism.

REPLACEMENT—The process by which one mineral or chemical substance takes the place of an earlier substance.

RIFT—Easiest direction of splitting of a rock. Usually parallel to the surface.

ROSETTE—Radiating as the petals of a flower.

ROSIWAL ANALYSIS—A statistical method of determining the volume percentages of the minerals of a rock.

"SAP"—Partly weathered upper few inches of pavements of granite or gneiss.

SAPROLITE—Weathered rock which retains its original structures.

SEDIMENTARY ROCKS—Rocks formed by the hardening of sediments deposited by water, wind, or glaciers.

SCHIST—Foliated metamorphic rock whose individual folia are mineralogically alike.

SCHISTOSITY—The property by which a foliated rock can be divided into thin flakes.

SERIATE—Inequigranular texture of an igneous rock.

SERICITIZED—Replacement of alumino-silicate minerals by sericite.

SERRATE—"Saw-toothed" texture.

SHEAR ZONES—Small shears or faults which may be filled with quartz, aplite or pegmatite veins.

SHEETING—Splitting of rock parallel to the surface.

SILLIMANITE ZONE—Metamorphic zone in which sillimanite is the index mineral.

SPALLING—Breaking off of chips or fragments of rock.

S-SURFACES—Any planar structures of a rock.

STAUROLITE ZONE—Metamorphic zone in which staurolite is the index mineral.

STRIATED—Covered with parallel scratches or grooves.

SUTURED—Irregular, interlocking contacts.

SYMPLECTITIC—Secondary intergrowth or interfingering of two minerals.

SYNCLINE—A structural trough.

SYNTECTONIC—Formed during deformation.

SYNTHETIC SHEAR—Shear or fault which forms at a low angle to the relative direction of movement.

TRANSVERSE FOLDS—Folds whose axes trend at approximately right angles to the major fold axes of a region.

TWINNING—An assemblage of two or more crystals, or parts of crystals, in reversed position with reference to one another in accordance with some twin law.

UNIVERSAL STAGE—Instrument used to orient a thin section in any desired position under a microscope.

XENOBLASTIC—Metamorphic minerals without crystal faces.

XENOLITH—An inclusion.

LIST OF ABBREVIATIONS AND SYMBOLS

An_{15} - - - The term "An" with its subscript indicates the percentage of anorthite molecule contained in plagioclase. An_{15} would contain 85% albite and 15% anorthite.

$N\alpha$ - - - - Smallest index of refraction of a biaxial mineral.

$N\beta$ - - - - Intermediate index of refraction of a biaxial mineral.

$N\gamma$ - - - - Largest index of refraction of a biaxial mineral.

N_e - - - - Index of refraction of the extraordinary ray in a uniaxial mineral.

N_o - - - - Index of refraction of the ordinary ray in a uniaxial mineral.

2V - - - - The true angle between optic axes of a biaxial mineral.

$Z \wedge c$ - - The angle between Z and c. Z is the vibration direction of the slowest ray or largest index of refraction of a biaxial mineral. C is the vertical crystal axis.

$r > v$ - - The 2V in red light is greater than the 2V in violet light.

$X > Y$, $X < Y$ - - Absorption greater (or less) in the X direction than in the Y direction.

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I N D E X – Continued

INDEX – Continued

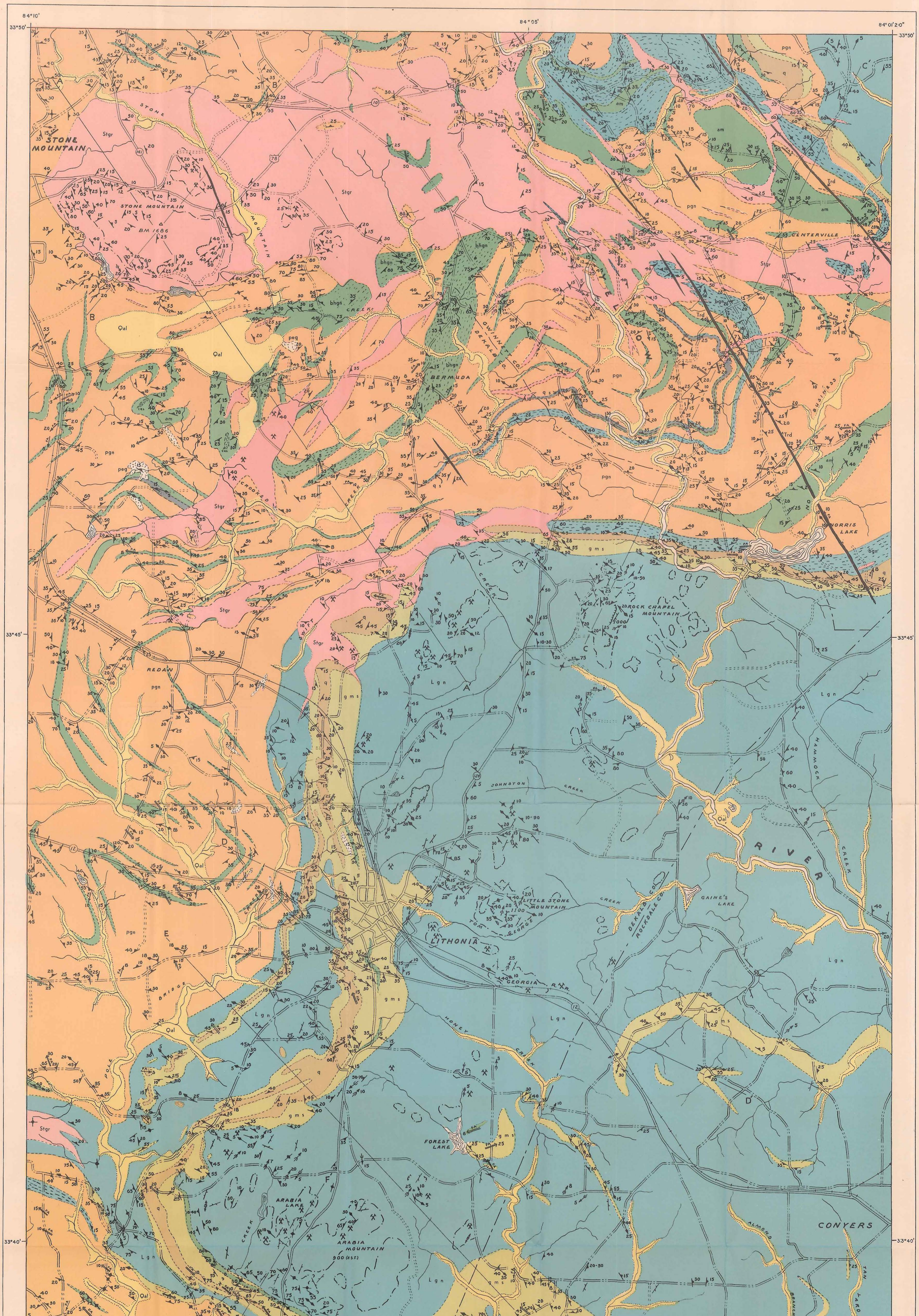


PLATE I

EXPLANATION

Qal — Quaternary

Alluvium

(Colluvium and Stream Alluvium)

IGNEOUS ROCKS

Trd — Triassic

Diabase dike

peg

Pegmatite dikes

Stgr — Permian (?)

Stone Mountain granite

METAMORPHIC ROCKS

Pre-cambrian (?)

pgn

Porphyroblastic biotite gneiss

(Includes porphyroblastic biotite gneiss, with interlayered amphibolite, fine-grained biotite gneiss, biotite schist, sillimanite-quartz schist, garnet-cummingtonite gneiss, garnetiferous kyanite gneiss, kyanite-muscovite schist, and phlogopite quartzite; abundant pegmatite dikes are instrusive into the gneiss)

bhgn

Biotite-hornblende gneiss

(medium-grained, well banded epidote-biotite-hornblende gneiss; often contains amphibolite bands)

am tas

Amphibolite

(includes epidote-pyroxene-hornblende gneiss, epidote-hornblende gneiss, and hornblende gneiss interlayered with biotite gneiss; the amphibolite occurs as fine-to medium-grained layers or lenses within porphyroblastic biotite gneiss.

tas; talc-actinolite-chlorite augen schist within certain amphibolite layers)

qs

Muscovite-quartz schist

(fine-to medium-grained muscovite-quartz schist)

bgn

Biotite gneiss

(medium-grained biotite gneiss; individual biotite and quartz-feldspar bands up to 3mm. wide)

q

Muscovite quartzite

(muscovite quartzite, locally contains garnet and kyanite)

gms

Garnet-mica schist

(garnet-muscovite-biotite schist with interlayered amphibolite and fine-grained biotite gneiss; sillimanite locally present)

MIGMATITE

Lgn

Lithonia gneiss

(medium-grained, evenly banded biotite gneiss with locally abundant garnet-rich layers; the rock has been dislocated along numerous shear zones, and migmatized by syntectonic aplite, pegmatite, and granite dikes)

CONTACTS

Observed contact

Float contact

Inferred contact

STRUCTURES

Strike and dip of: 1, banding; 2, schistosity; 3, flow foliation — 25

horizontal banding, etc.

vertical banding, etc.

strike and plunge of mica lineation — 15

horizontal mica lineation

strike and plunge of axes of small, tight folds — 10

horizontal fold axes

strike and plunge of axes of undulatory folds — 5

strike and plunge of flow fold axes — 10

horizontal flow fold axes

axes of muscovite fluctuation — 20

hornblende orientation — 15

strike of shear zones, with relative displacement

strike and dip of fault plane, with relative displacement — D U 60

SPECIAL SYMBOLS

pavement exposure

large quarry

small quarry

GEOLOGY AND STRUCTURE OF THE STONE MOUNTAIN-LITHONIA DISTRICT, GEORGIA

PLANIMETRIC BASE MAP PREPARED FROM FAIRCHILD AERIAL SURVEYS PHOTOGRAPHS OF DEKALB, ROCKDALE, AND GWINNETT COUNTIES, 1939-1940 FLIGHT. 25000 FOOT GRID CONTROL OBTAINED FROM ROAD MAPS OF DEKALB, ROCKDALE, AND GWINNETT COUNTIES. MAP DRAFTED IN 1950 BY L. HERRMANN

TRUE NORTH
MAGNETIC NORTH

SCALE

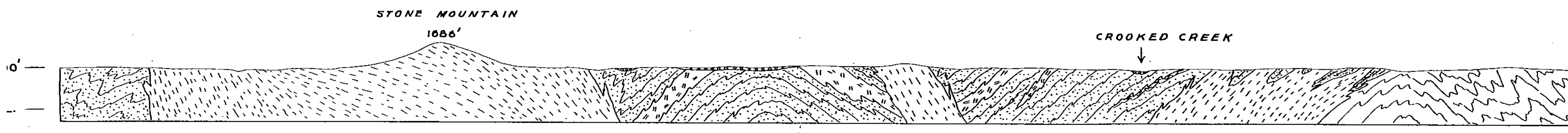
1 ½ 0 1 2 3 MILES

1000 500 0 1000 2000 3000 4000 5000 YARDS

GEOLOGY SURVEYED IN 1949 AND 1950 BY L. HERRMANN

PLATE 2

GEOLOGIC STRUCTURE SECTIONS OF THE STONE MOUNTAIN – LITHONIA DISTRICT, GEORGIA



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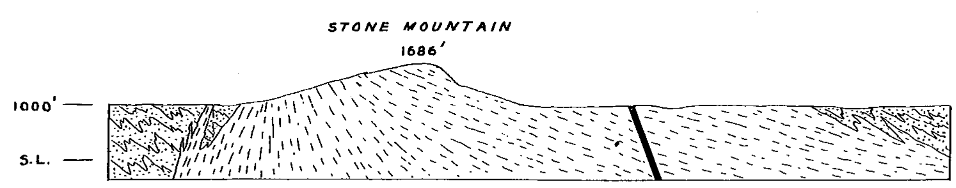

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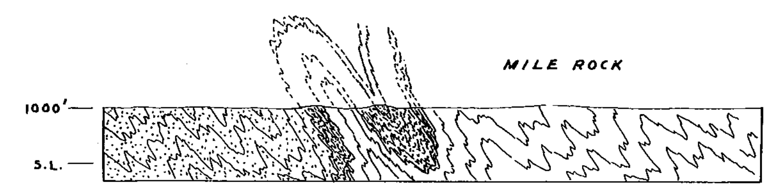
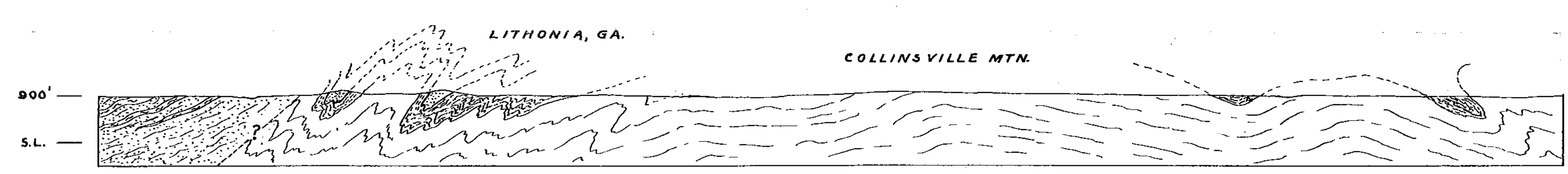


SECTION F - F'

SECTION C - C'



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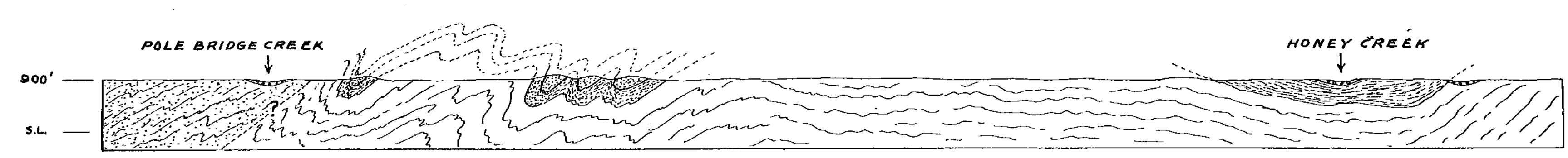
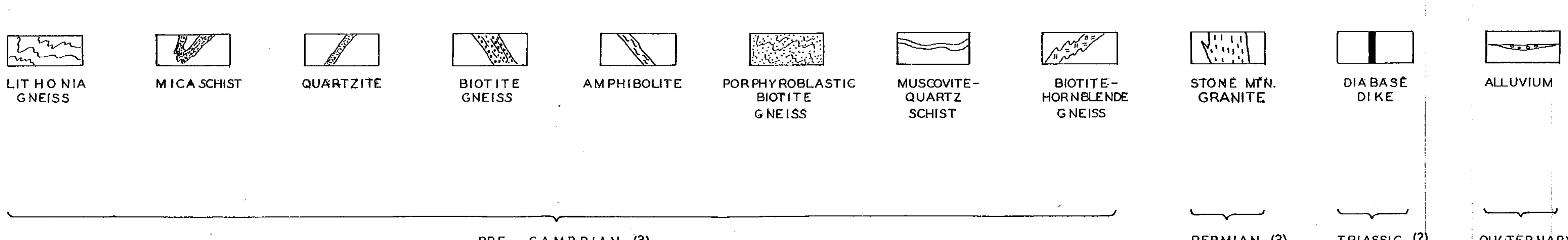


SECTION E - E'

LEGEND



LEO A. HERRMANN
1950

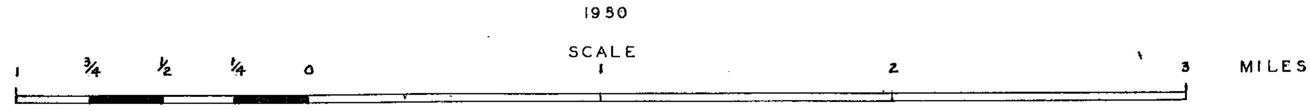
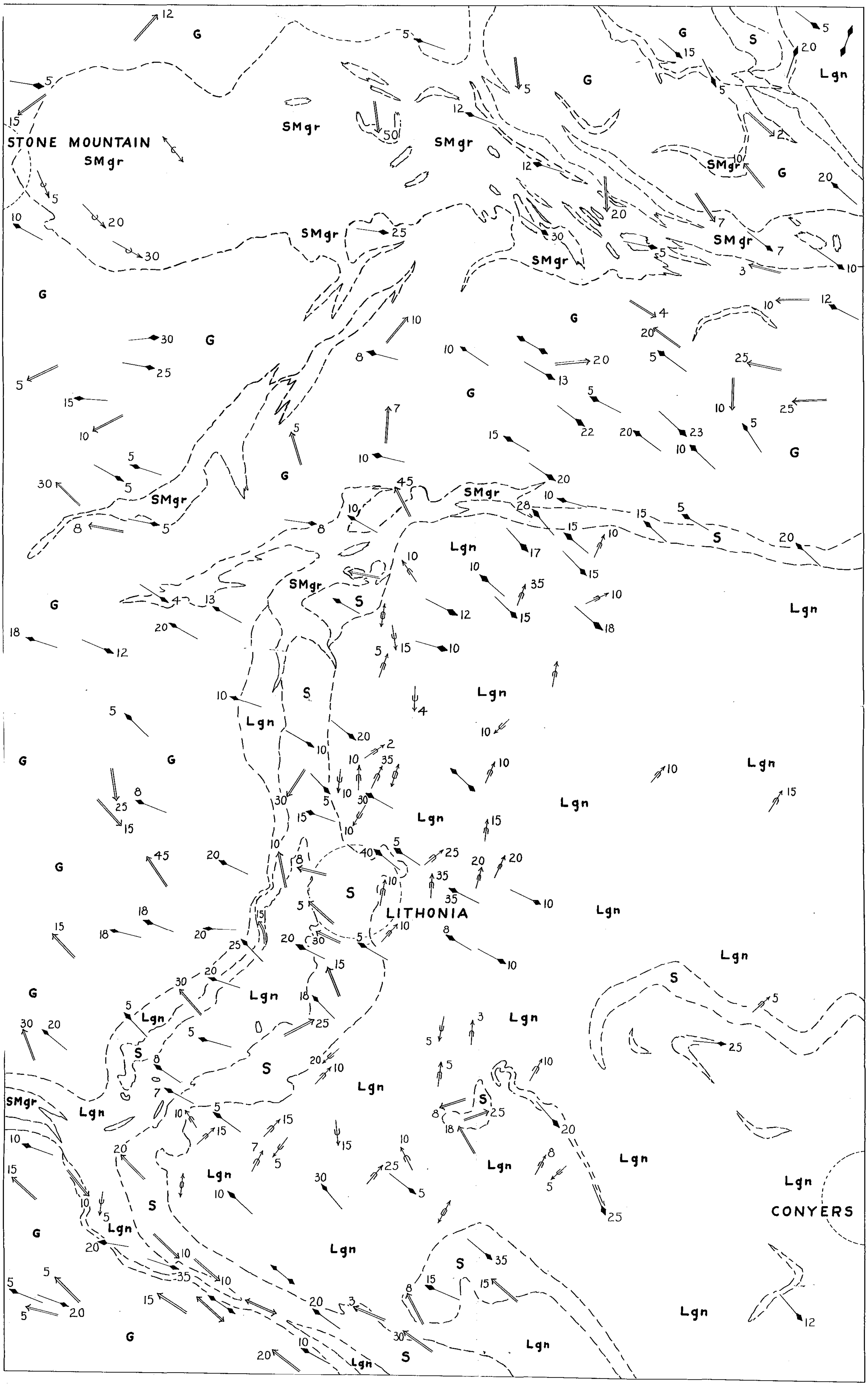


PLATE 3



LINEATION MAP OF THE STONE MOUNTAIN-LITHONIA DISTRICT, GA.

LINEATION SYMBOLS

- STRIKE AND PLUNGE OF AXES OF MUSCOVITE FLUCTUATION
- HORIZONTAL MUSCOVITE AXES
- STRIKE AND PLUNGE OF FLOW FOLD AXES
- HORIZONTAL FLOW FOLD AXES
- STRIKE AND PLUNGE OF MICA LINEATION
- HORIZONTAL MICA LINEATION
- STRIKE AND PLUNGE OF AXES OF MINOR FOLDS
- HORIZONTAL FOLD AXES

ROCK FORMATIONS

SMgr - STONE MOUNTAIN GRANITE

G - GNEISSES

S - MICA SCHIST AND QUARTZITE

Lgn - LITHONIA GNEISS

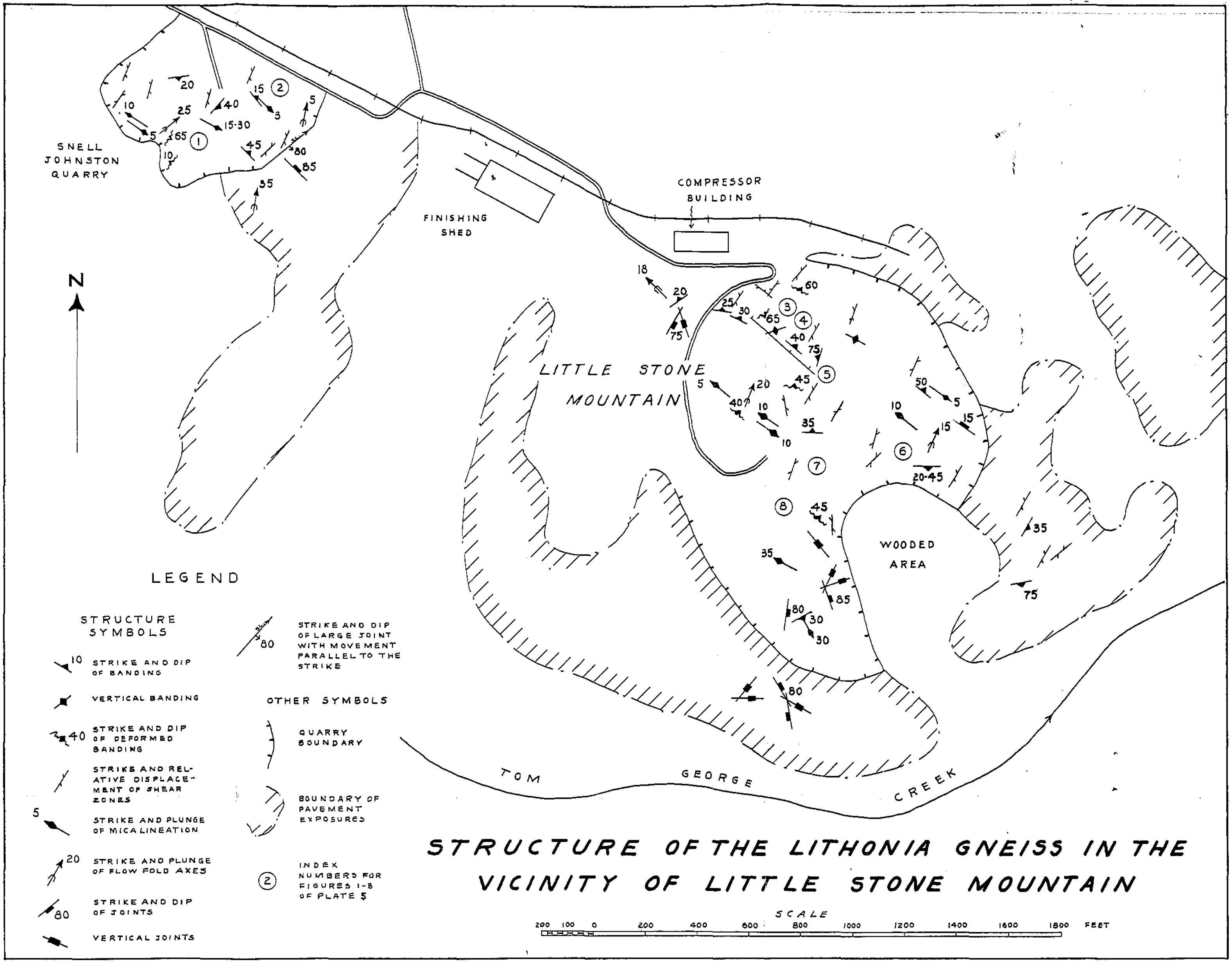
FORMATION BOUNDARIES

SCALE
IN MILES
0 1/4 1/2 1 2

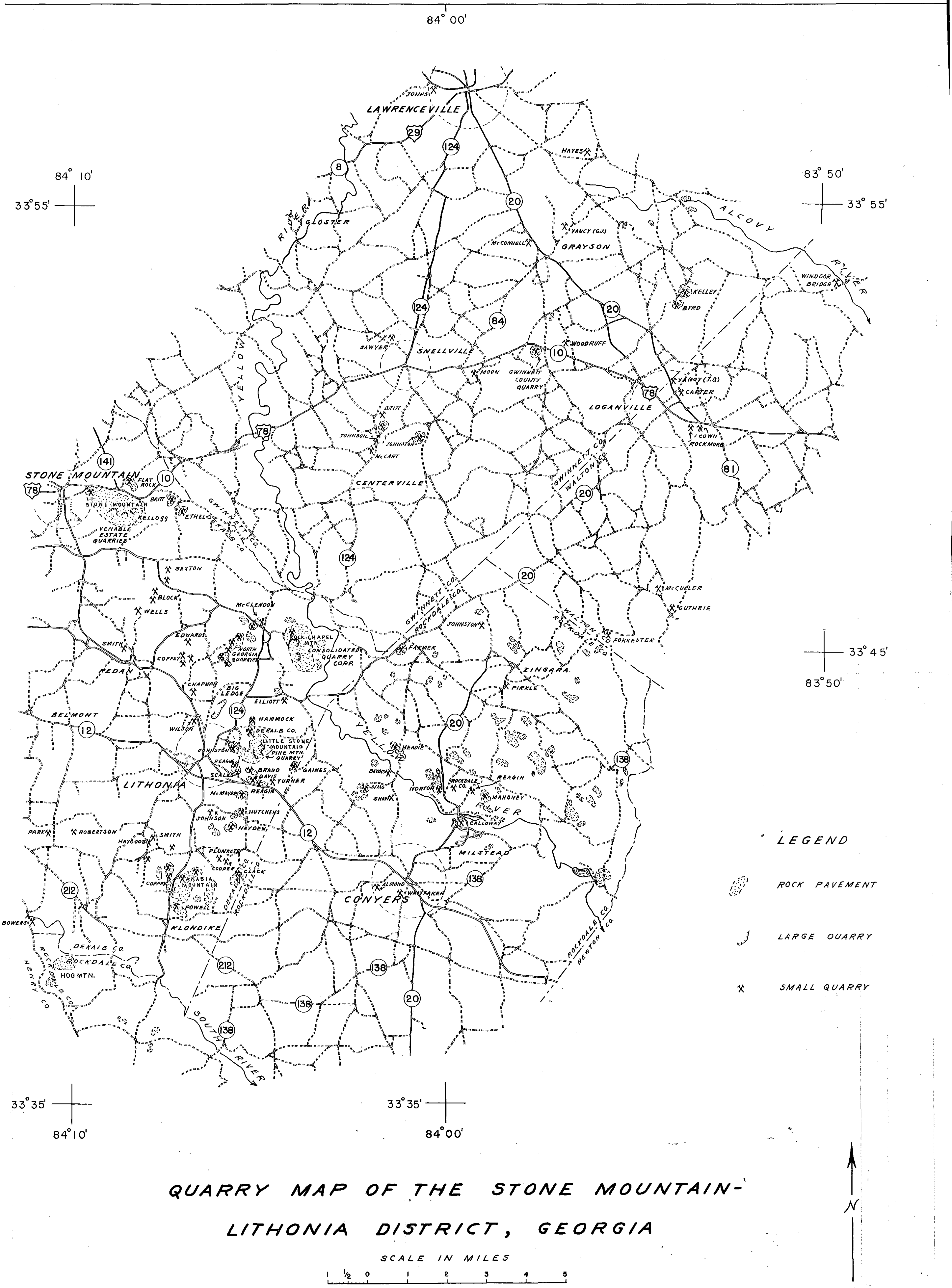
LEO A. HERRMANN
1951

INDEX MAP
84°10' 84°01'20"
33°50' 33°50'
33°37'23" 33°37'23"
84°10' 84°01'20"

PLATE 4



STRUCTURE OF THE LITHONIA GNEISS IN THE VICINITY OF LITTLE STONE MOUNTAIN



QUARRY MAP OF THE STONE MOUNTAIN-LITHONIA DISTRICT, GEORGIA

SCALE IN MILES

1 ½ 0 1 2 3 4 5

HIGHWAY NETWORK COMPILED FROM OFFICIAL COUNTY ROAD MAPS

LEO A. HERRMANN, 1952