THE GEOLOGY OF RABUN AND HABERSHAM COUNTIES, GEORGIA

BY

ROBERT D. HATCHER, JR.

THE GEOLOGICAL SURVEY OF GEORGIA
DEPARTMENT OF MINES, MINING AND GEOLOGY

Jesse H. Auvil, Jr.
State Geologist and Director

ATLANTA

1971

BULLETIN 83

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Georgia Department
of Mines, Mining and Geology

19 Hunter Street, S.W.
Atlanta, Georgia 30334
404/656-3214

Jesse H. Auvil, Jr.
State Geologist and Director

January 13, 1971

His Excellency, James E. Carter
Governor of Georgia and
Commissioner Ex-Officio
State Division of Conservation
Atlanta, Georgia

Dear Governor Carter:

I have the honor to submit herewith Georgia Geological Survey Bulletin 83, "The Geology of Rabun and Habersham Counties, Georgia," by Dr. Robert D. Hatcher, Jr. This report was supported under a contractual arrangement between Dr. Hatcher and the Georgia Department of Mines, Mining and Geology during the summer of 1970.

This excellent report, a reconnaissance investigation of the bed rock of Rabun and Habersham Counties, is a major contribution to the geology of the region. It is particularily involved with the structure of the rocks in this area. This bulletin will be extremely useful in the preparation of the new geologic map of Georgia.

Very respectfully yours,

Jesse H. Auvil, Jr.
State Geologist and Director

JHA:ldj

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CONTENTS

Page

CONTENTS—Continued

Figure

ILLUSTRATIONS

Page

PLATES

THE GEOLOGY OF RABUN AND HABERSHAM COUNTIES, GEORGIA: A RECONNAISSANCE STUDY

By

Robert D. Hatcher, Jr.

ABSTRACT

A reconnaissance investigation of the bedrock geology of Rabun and Habersham Counties, Georgia has been carried out. Earlier Precambrian (?) basement biotite and granitic gneisses were recognized in this area. The Tallulah Falls Quartzite has been renamed the Tallulah Falls Formation and it includes four members: the Graywacke-Schist-Amphibolite Member, the Garnet-Aluminous Schist Member, the Graywacke-Schist Member, and the Quartzite-Schist Member. The Graywacke-Schist and Quartzite-Schist members are thought to be stratigraphic equivalents. The Tallulah Falls Formation nonconformably overlies the basement gneiss units.

The Chauga River and Poor Mountain Formations were mapped in the Brevard Zone and Low Rank Belt of Habersham County. Granitic gneiss, biotite gneiss, sillimanite schist and amphibolite of unknown age were mapped on the mobilized Inner Piedmont of Habersham County. Later Paleozoic intrusions of granitic and ultramafic rocks occur in these two counties. Several dikes of Triassic (?) diabase also intrude the rocks of this area.

The rocks of Rabun and Habersham Counties have been affected by at least two, and possibly three, metamorphic events. Precambrian (Grenville ?) sillimanite grade metamorphism may be present in the basement rocks of the Blue Ridge. Mid-Paleozoic amphibolite facies (garnet to sillimanite grade) metamorphism is recognizable over the entire area. Later Paleozoic (Alleghanyan ?) cataclastic metamorphism characterizes the Brevard Fault Zone.

The Tallulah Falls Dome dominates the structure of the Blue Ridge of Rabun and Habersham Counties. It is interpreted as a nappe which has been arched by second generation folding. Erosion has breached the dome to expose the lower (synclinal) limb of the nappe and the basement rocks beneath.

INTRODUCTION

Rabun is the northeasternmost county in Georgia. It is bordered to the north by North Carolina and on the east by South Carolina. To the south is Habersham County. Together these two counties comprise an area of 600 square miles of some of the most complex and interesting geology in the Southern Appalachians (Figure 1). The topography of Rabun County is dominated by mountains with the backbone of the Blue Ridge crossing the middle and west side (Figure 2). Habersham County is mountainous to the north and west and is highly dissected to the southeast. The central and southwestern part of the county is an area of less abrupt topography made up of a portion of the Dahlonega Plateau described some years ago by LaForge, *et. al.* (1925).

Three geologic provinces are represented in these two counties: (1) the Blue Ridge; (2) the Brevard Zone, a narrow belt of the Low Rank Belt rocks (see Figure 1); and (3) the Inner Piedmont, composed of the mobilized high rank Inner Piedmont rocks. Most of the discussion herein will focus upon facts and speculation concerning the Blue Ridge portion of the map area, since there is relatively little of the Inner Piedmont present and because the Brevard rocks are poorly exposed in the areas visited during the study.

Rabun and Habersham Counties have been the subject of several mineral resource investigations (Hopkins, 1914; Galpin, 1915; Shearer and Hull, 1918; Prindle, 1935; Hunter, 1941; Furcron and Teague, 1943; 1945; Hurst and Crawford, 1964). Teague and Furcron (1948) made a combined mineral resource and geologic reconnaissance study of these two counties. Their geologic map is the most complete one published to date and clearly delineates the Tallulah Falls Dome, Brevard Zone, and several other major structural features in the two counties. It has served to stimulate several later studies, including the present one. Livingston and McKniff (1967) interpreted the Tallulah Falls Dome as a window in the Blue Ridge Thrust because of its similar tectonic position to the Grandfather Mountain Window, and because the distinct Tallulah Falls Formation dips under significantly different rocks on the flanks of the dome.

The present study was carried out during the summer of 1970

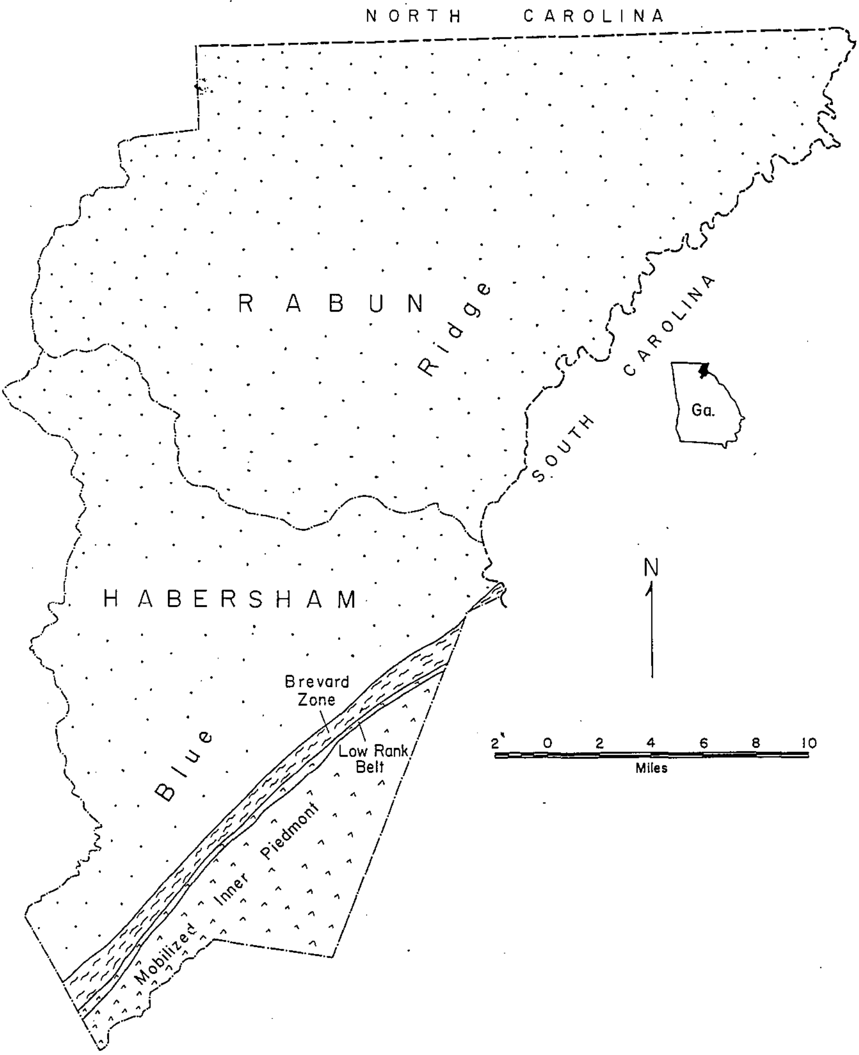

Figure 1. Map of Rabun and Habersham Counties, Georgia, showing the distribution of regional geologic provinces.

Figure 2. View of the southeast side of Rabun Bald and the *Blue Ridge* from the *Dahlonega* Plateau in South Carolina.

as a preliminary reconnaissance of Rabun and Habersham Counties prior to detailed mapping of this area. The detailed mapping will be carried out during 1971 and 1972. The objectives of this study were to look at as much of the two county area as possible in a relatively short time in order to delineate problem areas to be studied in detail later, to gather as much geologic data as possible, and to make a preliminary and somewhat speculative interpretation based upon the limited amount of data gathered. Parts of the interpretation to be presented here may be proved wrong in the face of additional data. It is felt, however, that the interpretation presented here is warranted given the available data, and will serve as a working hypothesis which can be modified or abandoned as dictated by data accumulated subsequently.

Mapping was restricted to road cut exposures. The inherent difficulties of this approach immediately became apparent: (1) not enough roads in some areas; and (2) not enough exposure along available roads in other areas. However, during the 50 man-days spent in the field in July and August of 1970, more than 2000 structural data stations were recorded. Most of the roads in the two counties were mapped. Data were recorded on 1/24,000 scale topographic maps as they were gathered, and compiled at the same scale. The geologic map (Plate 1) was first constructed on this scale as well, and then transferred to a county road map base. The quality and reliability of geologic contacts is distinguished on the resultant map (Plate 1).

Acknowledgements

This study was made possible through the contracted support of the Georgia Department of Mines, Mining and Geology. I would also like to express my gratitude to J. E. Wright, Jr., senior geology major at Clemson University, for his assistance in the field, laboratory, and in the compilation of the fabric data. National Science Foundation Grant GA-20321 provided field expenses and salary for Mr. Wright, for which I am also grateful.

ROCK UNITS

Introduction

The description of the different rock units to follow is based

Figure 3A. Migmatitic Biotite Gneiss unit at Woodall Shoals on the Chattooga River (Georgia-South Carolina state line). Lenses of amphibolite are present in the gneiss here.

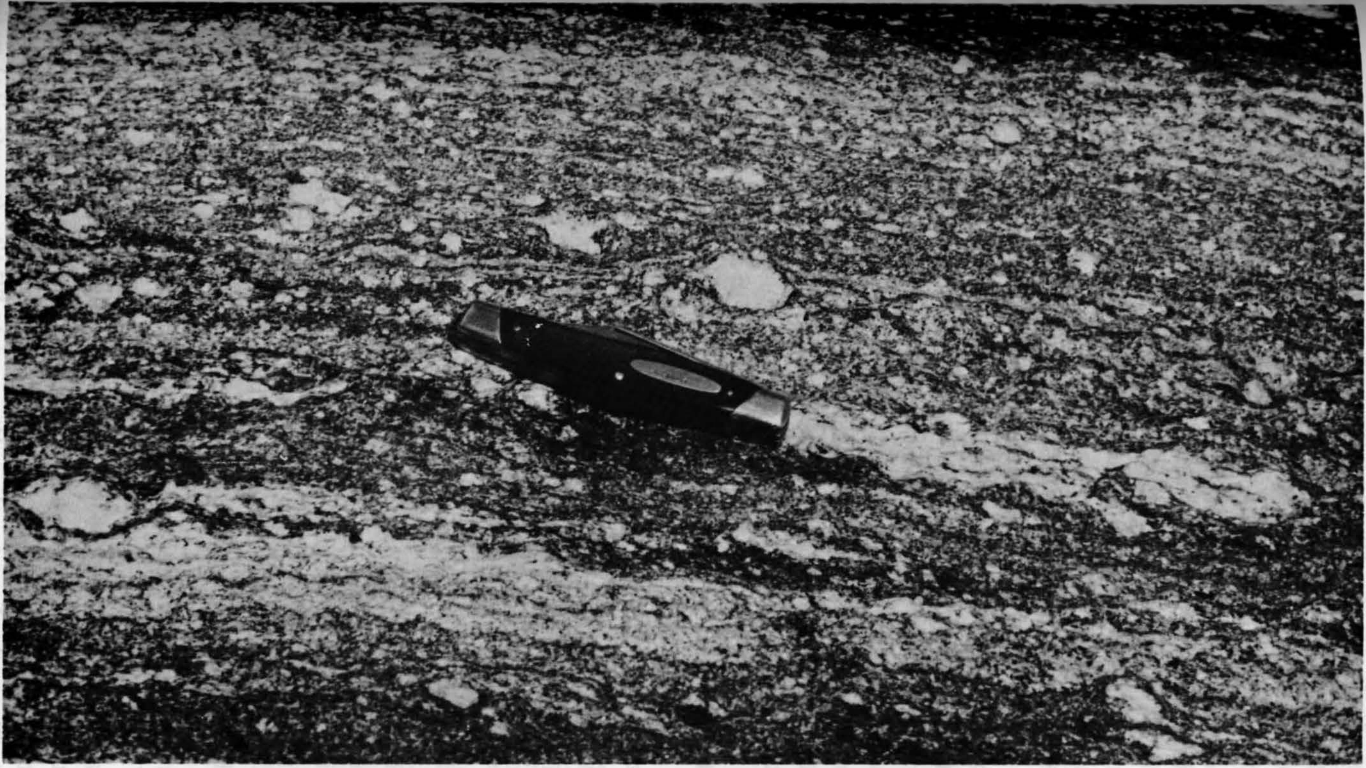

Figure 3B. Closer view of the Migmatitic Biotite Gneiss at the same locality.

upon two sources of information: (1) field and hand specimen descriptions; and (2) X-ray diffraction study of some 40 samples of most of the rock units. Few thin sections were available because of the short time span spent in this study and the amount of time needed to produce an adequate number of thin sections for petrographic descriptions.

Inner Piedmont Rocks-Rocks of Unknown Age

Gneiss-Schist-Amphibolite (ipgsa). Rocks of the Gneiss-Schist-Amphibolite unit include coarse-grained biotite-quartz-oligoclase-andesine-(microcline) gneiss, muscovite-biotite-sillimanite-quartz schist, hornblende-andesine-(biotite) amphibolite and amphibole gneiss, and minor amounts of feldspathic quartzite. Subdivision of this unit is impossible where only road cut exposures are examined. However, the writer believes that subdivision is possible and would be very fruitful in delineating the structure in a portion of Habersham County.

Granitic Gneiss (ipgg). The Granitic Gneiss unit of the Inner Piedmont consists of concordant bodies of medium- to coarse-grained quartz monzonite to granodiorite gneiss (oligoclase-microcline-quartz-biotite), which extends across the southeastern corner of Habersham County (Plate 1). The granite gneiss unit is distinguished from the migmatitic biotite gneiss and biotite gneiss unit by its finer grain size, higher potash feldspar content, lower biotite content, and lack of interlayers of mica schist.

Age Relations. No crosscutting of the enclosing rocks was observed and the granitic gneiss unit is thought to be syntectonic, derived from mobilization of the continental basement during the Mid-Paleozoic folding-metamorphic event. Both the granitic gneiss and the gneiss-schist-amphibolite unit are migmatitic, exhibiting abundant evidence of widespread granitization.

Earlier Precambrian (?) Rocks-Basement Rocks

Migmatitic Biotite Gneiss (PCbgm) and Biotite Gneiss (PCbg). The Migmatitic Biotite Gneiss [coarse oligoclase-quartz-biotite-(microcline-muscovite) gneiss and biotite-muscovite-oligoclase-quartz schist] and biotite gneiss [coarse oligoclase-quartz-biotite-(muscovite) gneiss] units are thought to be equivalent (Plate 1). The former is thought to be of higher metamorphic grade than the latter and has been partially to severely granitized. The migmatitic biotite gneiss contains abundant pods, stringers and thin layers of coarse granitic gneiss (quartz-microcline-oligoclase-biotite gneiss), amphibolite, and syntectonic pegmatites which in places grade into the migmatitic biotite gneiss (Figure 3). These are distinctly less abundant in the biotite gneiss unit. Both types of biotite gneiss contain appreciable amounts of quartz and in places could be classified as metagraywacke. The biotite content may also increase sufficiently so that these rocks could be classed as schists. Lenses or boudins of amphibolite are also common in these units. These could represent broken-up feeder dikes that supplied volcanic material for the lower part of the Tallulah Falls Formation.

Granitic Gneiss (PCgg). The Granitic Gneiss is a quartz diorite to quartz monzonite gneiss (coarse oligoclase-quartz-microcline-biotite gneiss) that is in places concordant with the host rocks but appears in others to be somewhat discordant.

Later Precambrian Rocks

Hornblende Gneiss and Amphibolite (PChg). The Hornblende Gneiss-Amphibolite unit consists of coarse-grained, well foliated hornblende-andesine-(quartz-epidote) gneiss or amphibolite, depending upon the percentage of hornblende in the rock (Figure 4). It appears to rest upon the migmatitic biotite gneiss unit and does not exhibit the migmatitic character of the biotite gneiss. It is therefore grouped with the Later Precambrian units. In the west-central part of the map this unit could be the lowermost member of the Tallulah Falls Formation, since it directly underlies the Graywacke Member in that area. The Hornblende Gneiss-Amphibolite unit is thought to be derived from metamorphism of mafic volcanic rocks.

Tallulah Falls Formation (PCt). The name Tallulah Falls Formation is proposed here to include the rocks formerly known as the Tallulah Falls Quartzite (Galpin, 1915) and Whetstone Group (Hatcher, 1969). Since the most persistent members of the two units are the Quartzite and Graywacke Members, and the name Tallulah Falls Quartzite takes precedence over Whetstone, the writer has chosen to change the

Figure 4. Typical fresh exposure of amphibolite on the Hornblende Gneiss and Amphibolite unit on the northwest side of the map area. Exposure located on U. S. 76 west of Clayton.

name Tallulah Falls Quartzite to Tallulah Falls Formation and include the quartzite as a member. Perhaps a better reason for this classification is that several lithologies, notably metagraywacke and pelitic schist, recur throughout all members of the formation thereby tying the unit together genetically.

The Tallulah Falls Formation consists of four members: the basal Graywacke-Schist-Amphibolite Member overlain by the Garnet-Aluminous Schist Member, which is succeded by the Graywacke-Pelitic Schist Member and its presumed facies equivalent, the Quartzite-Schist Member. Teague and Furcron (1948) mapped the Quartzite-Schist and Graywacke-Schist Members as the Tallulah Falls Quartzite.

Graywacke-Schist-Amphibolite Member (PCtl). The Graywacke-Schist-Amphibolite Member consists of beds of medium-grained quartz-oligoclase-biotite-muscovite metagraywacke, medium- to coarse-grained muscovite-(biotite-quartz-oligoclase) schist and layers of coarse-grained hornblende-andesine-(biotite) amphibolite. This unit, where present, rests directly upon the basement rocks and varies in thickness from 0 to perhaps 3000 feet. Exact thickness of this unit or any other in this area, is indeterminate because of internal folding and repetition of portions of the unit and/or large scale tectonic thickening or thinning by flowage. The term apparent thickness will be used here to refer to this dimension.

Garnet-Aluminous Schist Member (PCtp). The Garnet-Aluminous Schist Member either overlies the Graywacke-Schist-Amphibolite Member in sequence or rests directly upon basement where the Graywacke-Schist-Amphibolite Member is missing (Plate 1). The Garnet-Aluminous Schist Member is composed predominately of medium- to coarse-grained muscovite-almandine-(biotite-quartz-oligoclase) schist. Kyanite or sillimanite may be present, depending upon metamorphic grade and whether excess alumina is present in the rock. Commonly interbedded with this lithology are layers of medium- to coarse-grained muscovite-(biotite-quartz) schist and medium-grained quartz-oligoclase-biotite-muscovite metagraywacke ranging from a few inches to more than a foot in thickness. The apparent thickness of this unit varies from a few feet to about 700 to 800 feet.

Graywacke-Schist Member (PCtg). The Graywacke-Schist Member consists of medium to thick beds of medium- to coarse-grained quartz-oligoclase-biotite-muscovite metagraywacke interlayered with medium- to coarse-grained muscovite-(biotite-quartz) schist. Occasional amphibolite and quartz-(oligoclase-biotite-muscovite) quartzite also occur in this unit. It is not uncommon to observe graded metagraywacke-Schist beds and in some places tops may be determined although metamorphism frequently has obscured gradational boundaries between beds. The apparent thickness of this unit varies from 500 to 2000 feet.

Quartzite-Schist Member (PCtq). The Quartzite-Schist Member consists of thickly bedded medium- to coarse-grained quartzite interbedded with medium- to coarse-grained muscovite-(biotite-quartz) schist layers up to 4 feet in thickness (Figure 5). Graded beds are common and in places within the unit the quartzite is conglomeratic. The basal 25 feet of the quartzite in the area near the basement contact on the Tallulah Falls Dome (Plate 1) is a series of metaconglomerate beds. Each bed grades upward into quartzite, then into schist partings (Figure 6). The apparent thickness of the Quartzite-Schist Member is estimated to range from 0 to 3000 feet (Plate 2).

A thin section of the quartzite reveals that the rock is predominately quartz with minor almandine, oligoclase, biotite, muscovite, calcite, and microcline. Minor accessory minerals include zircon and tourmaline. X-ray analysis of the conglomerate indicated a predominance of quartz with minor oligoclase, biotite and microcline.

Cambrian-Precambrian (?) Rocks-Brevard Zone and Low Rank Belt

Brevard Mylonite Zone (cz). Although the rocks that compose the Brevard Mylonite Zone are probably of Cambrian or Precambrian age, most of the cataclastic textures and structures that characterize this unit are thought to have formed during the Late Paleozoic (Alleghanyan) deformational event (Hatcher, in press). The mylonite zone is a narrow belt of cataclastic rocks occupying the northwest side of the Brevard Zone. It is characterized by the presence of fine-grained flinty mylonites, but these rocks are not unique to this part of the Brevard Zone. However, most mylonites occur here, perhaps

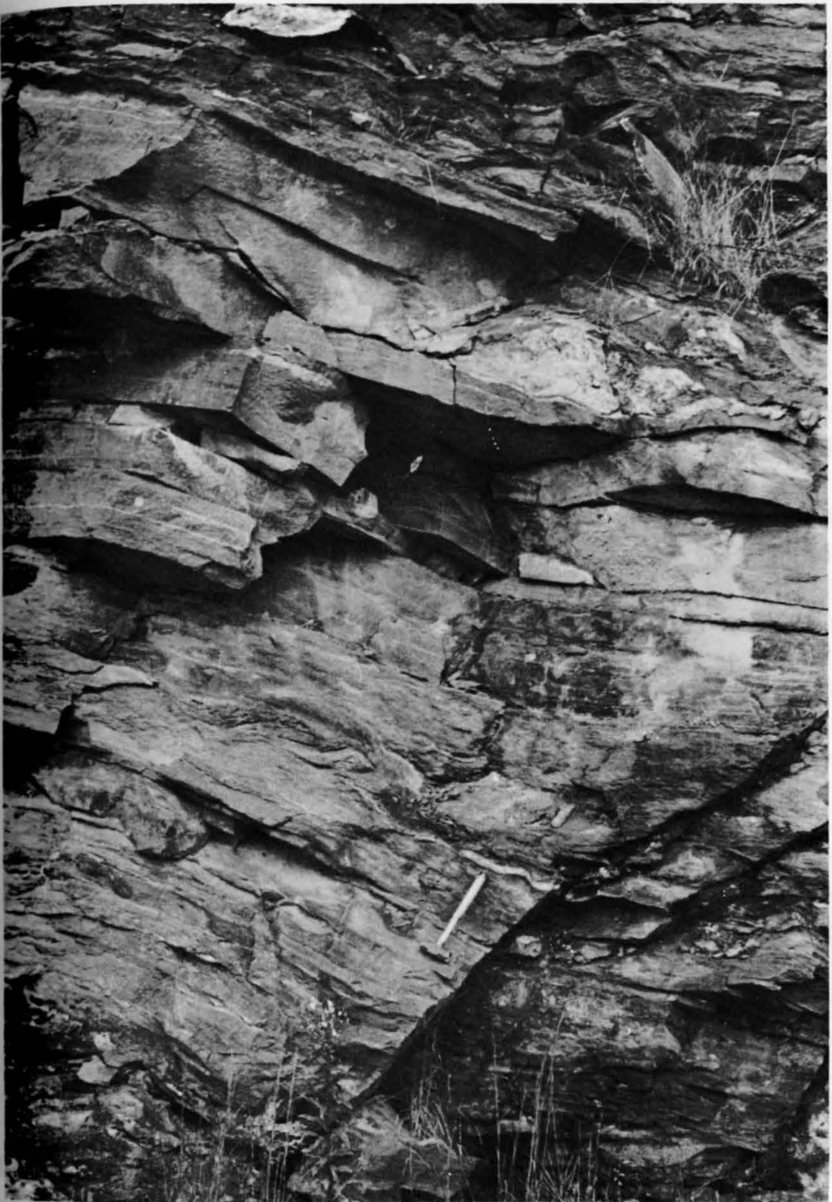

Figure 5. Thick beds of quartzite of the Quartzite-Schist Member of the Tallulah Falls Formation exposed on U. S. 441 south of Clayton near the Rabun-Habersham County line.

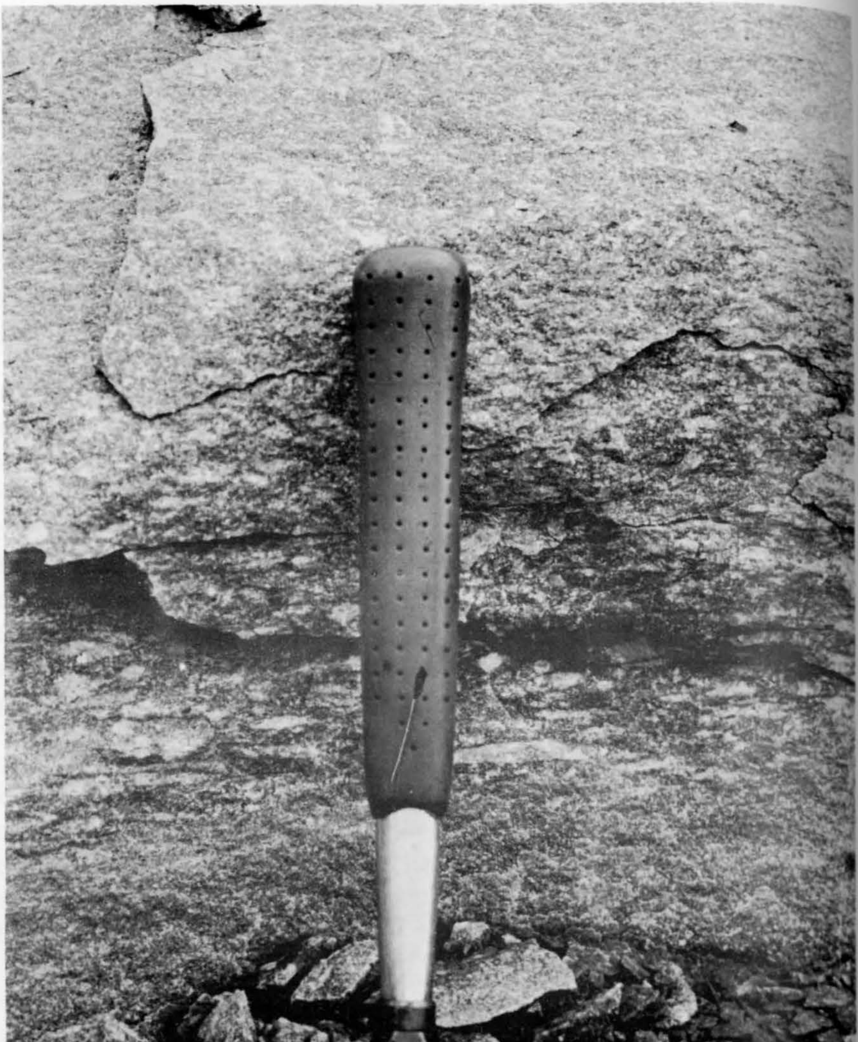

Figure 6. Upright graded bed of conglomeratic quartzite near the base of the Quartzite-Schist Member of the Tallulah Falls Formation. Note the extreme flattening and elongation of pebbles. Located on U. S. 441 just east of Wiley.

because the Brevard Zone was buttressed against a group of quartzofeldspathic rocks to the northwest and these were crushed and granulated during faulting. The mylonites are composed of very fine-grained quartz with minor oligoclase and muscovite. The principal mylonite zone does not appear to be as thick in Habersham County as in northwestern South Carolina (Hatcher, 1969; Hatcher and Griffin, 1969) and is estimated to have a maximum thickness of 200 to 300 feet.

Chauga River Formation. The name Chauga River Formation was proposed by Hatcher (1969) for the stratigraphic sequence that exists in the Brevard Zone of South Carolina and adjacent North Carolina and Georgia. All the members composing the formation have been recognized in Habersham County, Georgia, and its estimated thickness of 1500 feet for South Carolina appears to be consistent for this area. Although the writer did not directly observe the Carbonate Member, Teague and Furcron (1948), Pruitt (1952) and Hurst and Crawford (1964) have mapped the unit across all or portions of the county. The writer has mapped the member as being exposed along Panther Creek in Stephens County between the Georgia-South Carolina State line and the Stephens-Habersham County line. Although the Carbonate Member was not observed in Habersham County, its position in the Brevard Zone is readily determined from the topographic lineament (a topographic low and alignment of streams) that accompanies the member. A similar topographic low was found by the writer at about the same position in the Brevard Zone in South Carolina (Hatcher, 1969, p. 110). Hurst and Crawford (1964) used aerial photographs to trace the unit across Habersham County. Due to the fact that the unit was not actually observed here by the writer, it is shown on the geologic map by inferred contacts (Plate 1).

Lower Brevard Phyllite Member (bp). The Lower Brevard Phyllite Member consists of a fine- to medium-grained greenish gray muscovite-chlorite-quartz-(sodic oligoclase) phyllite in which a considerable proportion of the muscovite occurs as augen. These augen give the rock a button or fish-scale appearance, with the rock appearing to consist entirely of overlapping augen. Mapped with this member is the basal Graphitic Phyllite Member, a dark gray fine-grained muscovite-chlorite-quartz-graphite-(oligoclase) phyllite. Interbedded with both these members is some impure quartzite.

Carbonate Member (crc). As discussed above, the Carbonate Member of the Chauga River Formation has not been observed by the writer in Habersham County. Throughout South Carolina and Stephens County, Georgia, the carbonate is a medium gray calcite-quartz-(muscovite-chlorite-oligoclase) marble which in many places contains quartz augen. From the descriptions of other workers in this area (Teague and Furcron, 1948; Hurst and Crawford, 1964), the carbonate is similar to that exposed in other places.

Upper Brevard Phyllite Member (bp). The Upper Brevard Phyllite Member consists predominately of the same muscovite-chlorite phyllite as the lower member. The only significant difference between the two units is that in some areas there is more interlayered impure feldspathic quartzite present.

Poor Mountain Formation. The Poor Mountain Formation (Hatcher, 1969) is made up of several members. Brevard-Poor Mountain Transitional, Amphibolite and Marble-Quartzite members compose the formation. Due to the narrow exposure of the Low Rank Belt in this part of Georgia, only the lowest member, the Brevard-Poor Mountain Transitional Member, is represented in Habersham County (Plate 1).

Brevard-Poor Mountain Transitional Member (bpm). Most of the Brevard-Poor Mountain Transitional Member is composed of fine- to medium-grained greenish-gray muscovite-quartz-chlorite-(biotite-oligoclase) phyllitic metasiltstone along with some fine- to medium-grained light to medium gray quartz-sodic oligoclase-biotite-(chlorite-muscovite) metagraywacke. The members grade into one another and some thin layers of fine-grained dark gray-green actinolitic-hornblende quartz-oligoclase-(biotite-epidote) amphibolite with interlayers of fine-grained quartz oligoclase-(biotite) metaquartzite are present in this area.

Later Paleozoic Intrusives (Post Metamorphic)

Granitic Rocks (PZg). The only area thought to be underlain by Later Paleozoic granitic rocks in the mapped area is that in the north central part of Rabun County (Plate 1). This rock unit is thought not to have undergone regional metamorphism because of its marked homogeneity and lack of conspicuous foliation. It is coarse-grained and porphyritic, and is composed of oligoclase, quartz, microcline, and biotite with phenocrysts of perthitic microcline up to one inch in length.

Ultramafic Rocks (PZum). Ultramafic rocks encountered during this study include several bodies of dunite and peridotite in varying stages of alteration (Plate 1). Many more of these bodies were noted in this area by Hopkins (1914) and Hurst and Crawford (1964) and two were described by Hunter (1941). These latter, the Laurel Creek Dunite and the dunite on U. S. 76 west of Clayton (Figure 7), are two of the bodies observed during this investigation, and are perhaps the largest ultramafic bodies in this area. The Laurel Creek body is particularly notable because of its varied mineralogy. The primary rock material is dunite but this has been altered in part to a variety of talc (soap stone) and serpentine zones surrounding a remnant core of dunite. Corundum, tourmaline and asbestos (anthophyllite) are also present. Abundant evidence of corundum mining over 100 years ago is still present there. A detailed study of the Laurel Creek body by J. E. Wright, Jr., as a Senior Research Project at Clemson University, under the direction of the writer, is presently in progress.

Triassic (?) Rocks

Diabase (TRd). Several dark gray diabase dikes were found during the course of the study (Figure 8; Plate 1). They are unmetamorphosed and generally cut across the regional structural grain. One thin section of diabase from this area is composed of a hypidiomorphic granular mixture of interlocking labradorite and augite grains with some phenocrysts of augite and calcic andesine or labradorite. The rock is generally medium-grained, and phenocrysts may be observed in hand specimen.

STRUCTURAL DATA

Some 2000 structural data stations were recorded during the course of the investigation. Included in this assemblage of data are dip and strike measurements on foliation and compositional layering, fold axes, slip-cleavage and other lineations.

Figure 7. Exposure of a partially weathered surface of dunite in the dunite body on U. S. 76 west of Clayton.

Figure 8A. Triassic (?) diabase dike intruding amphibolite and hornblende gneiss on State Highway 197 near Lake Burton. Dike is about 15 feet in thickness.

Figure 8B. Xenoliths of hornblende gneiss along the margin of a smaller diabase dike (about 10 feet thick) at the same locality as above.

Mesoscopic Structural Elements

The most prominent structural feature of the Blue Ridge of Rabun and Habersham Counties is the Tallulah Falls Dome. From an examination of the dip-strike data on the geologic map (Plate 1), or in figure 9, the reader can readily discern that the extent of the dome is not limited to the circular outcrop area of the Tallulah Falls Formation but extends well into the basement rocks. However, even with extensive areas of northwest, southwest and northeast dip of the rocks in these two counties, the regional southeast dip still prevails these two counties (Figures 9 and 10).

Relatively few lineation measurements were made during the course of the study. The principal lineation observed is the crystallization lineation resulting from the crystallization of micas, quartz and feldspars in such a manner as to give the rock a spindled appearance. These data are presented in figure 11. It is thought that this is a *b* lineation, since the dominant trends parallel the dominant isoclinal fold trends. At only one locality was the northwest-trending mineral streaking lineation observed. This is thought by Reed and Bryant (1964) to be an *a* lineation related to the northwestward tectonic transport of the Blue Ridge Thrust Sheet (Figure 12).

Numerous mesoscopic folds are present in the Blue Ridge rocks of this area. These follow three trends: (1) a N 50° E trend; (2) a N 20° E trend; and (3) a lesser cross trend of N 40° W to N 60° W (Figure 13). The northwest trend is dominated by a flexural slip (open) style of folding, although isoclines do occur here, while the other two trends are predominately isoclinal and isoclinal recumbent passive flow folds (Figures 14 and 15). Flexural flow folding may also be an important mechanism of folding here (Figure 16).

Slip-cleavage (crinkle lineation) has a very consistent attitude (Figure 17). However, most of these measurements were recorded in one particular area (Plate 1) on the south flank of the Tallulah Falls Dome and the trend may consequently reflect some local rather than regional movement.

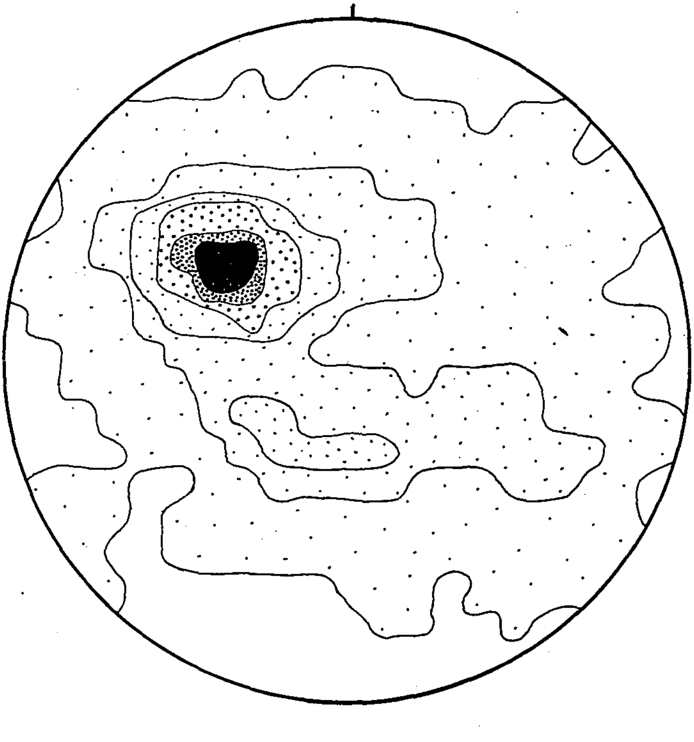

Figure 10. Synoptic diagram of 1737 poles to foliation and compositional layering from the Blue Ridge of Rabun and Habersham Counties. Contours 9%, 7%, 5%, 3%, 1%, and 0.1% per 1% area.

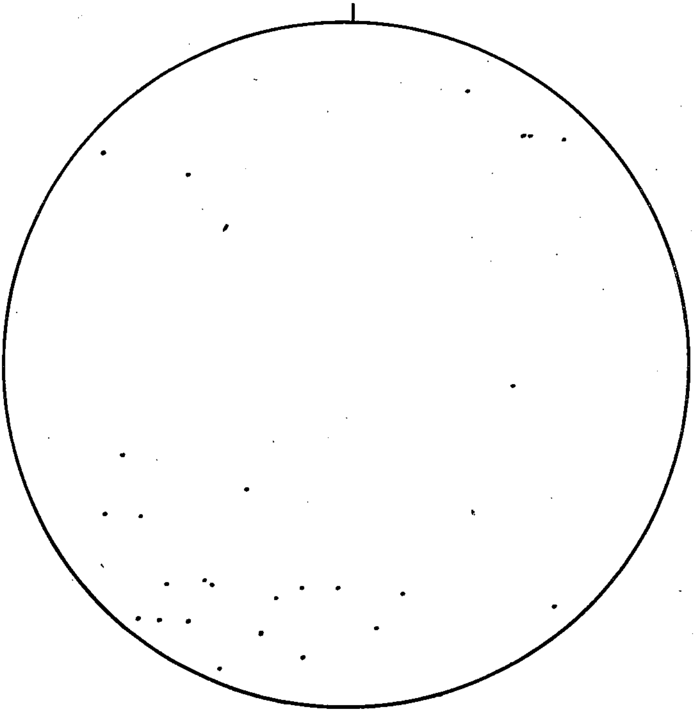

Figure 11. Point diagram of 16 crystallization lineations from the Blue Ridge of Rabun and Habersham Counties.

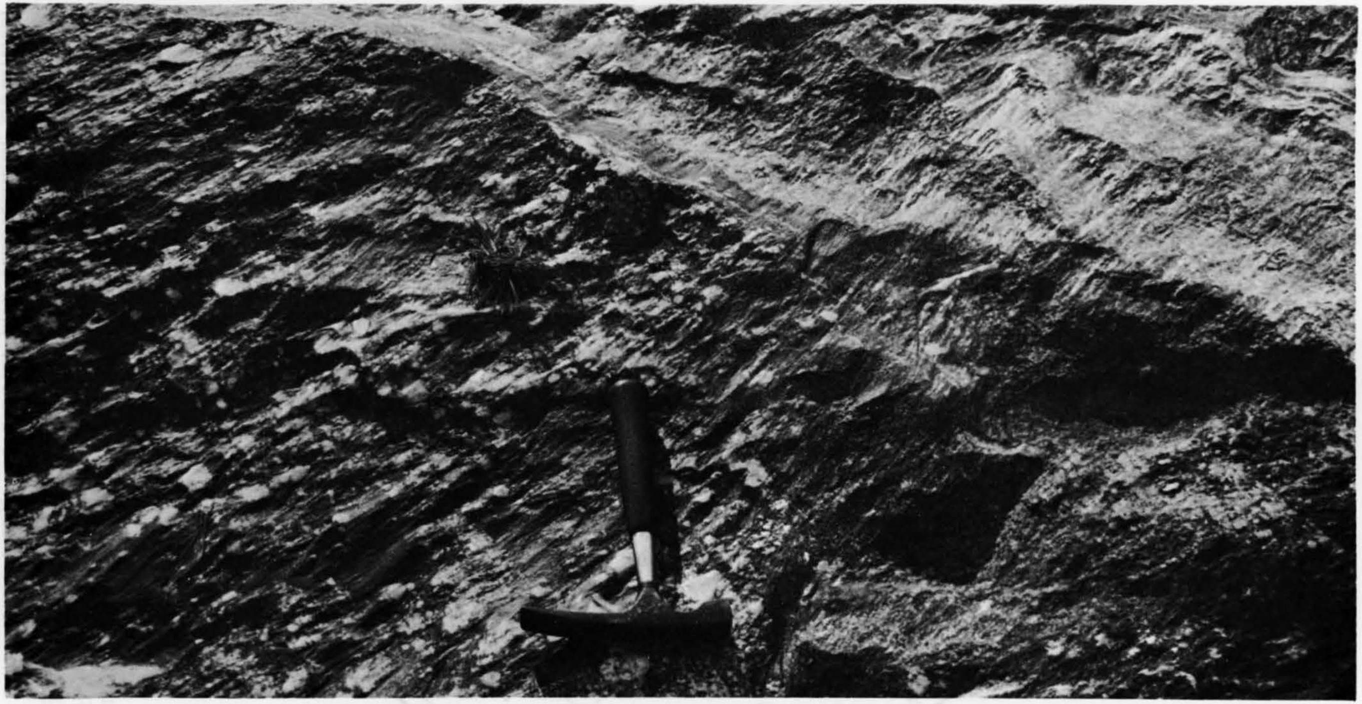

Figure 12. Mineral streaking lineation exposed on foliation surfaces at Woodall Shoals on the Chattooga River on the Georgia-South Carolina state line. This is thought to be an *a* lineation related to movement within the Blue Ridge Thrust Sheet. Its strike is N 49° W and plunges 22° southeast.

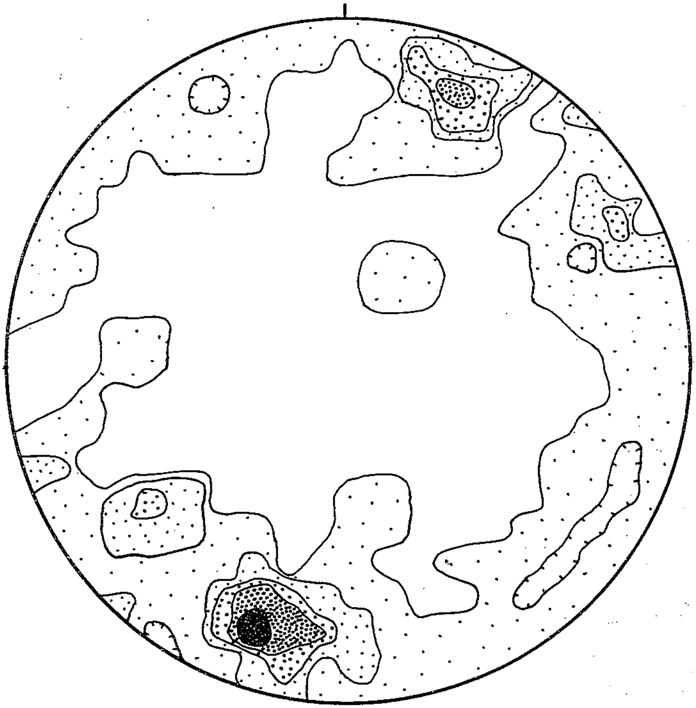

Figure 13. Synoptic diagram of 84 fold axes from the Blue Ridge of Rabun and Habersham Counties. Contours 9%, 7%, 5%, 3%, and 1% per 1% area.

Figure 14. Flexural-slip fold in Migmatitic Biotite Gneiss at Woodall Shoals on the Chattooga River.

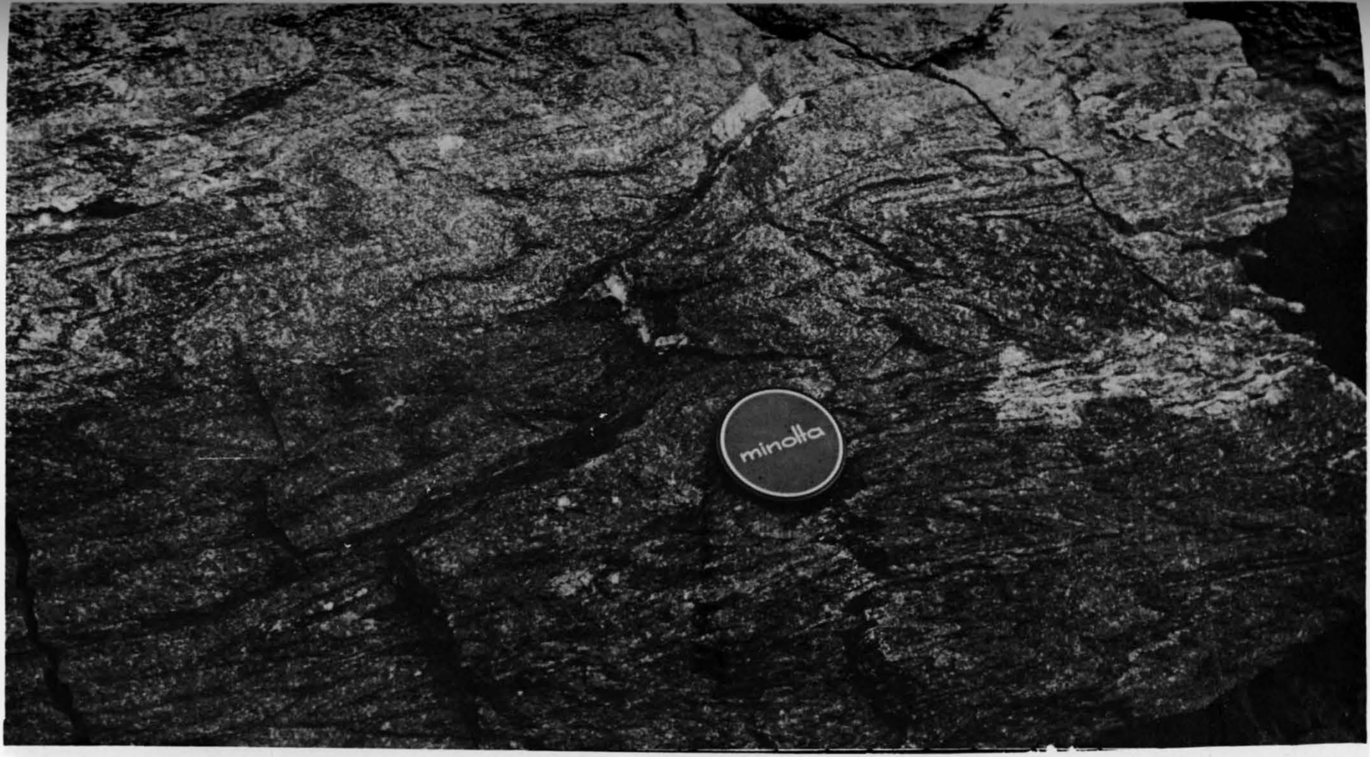

Figure 15A. Passive flow folds in the Graywacke-Schist Member of the Tallulah Falls Formation. Located on U. S. 441 southeast of Tiger.

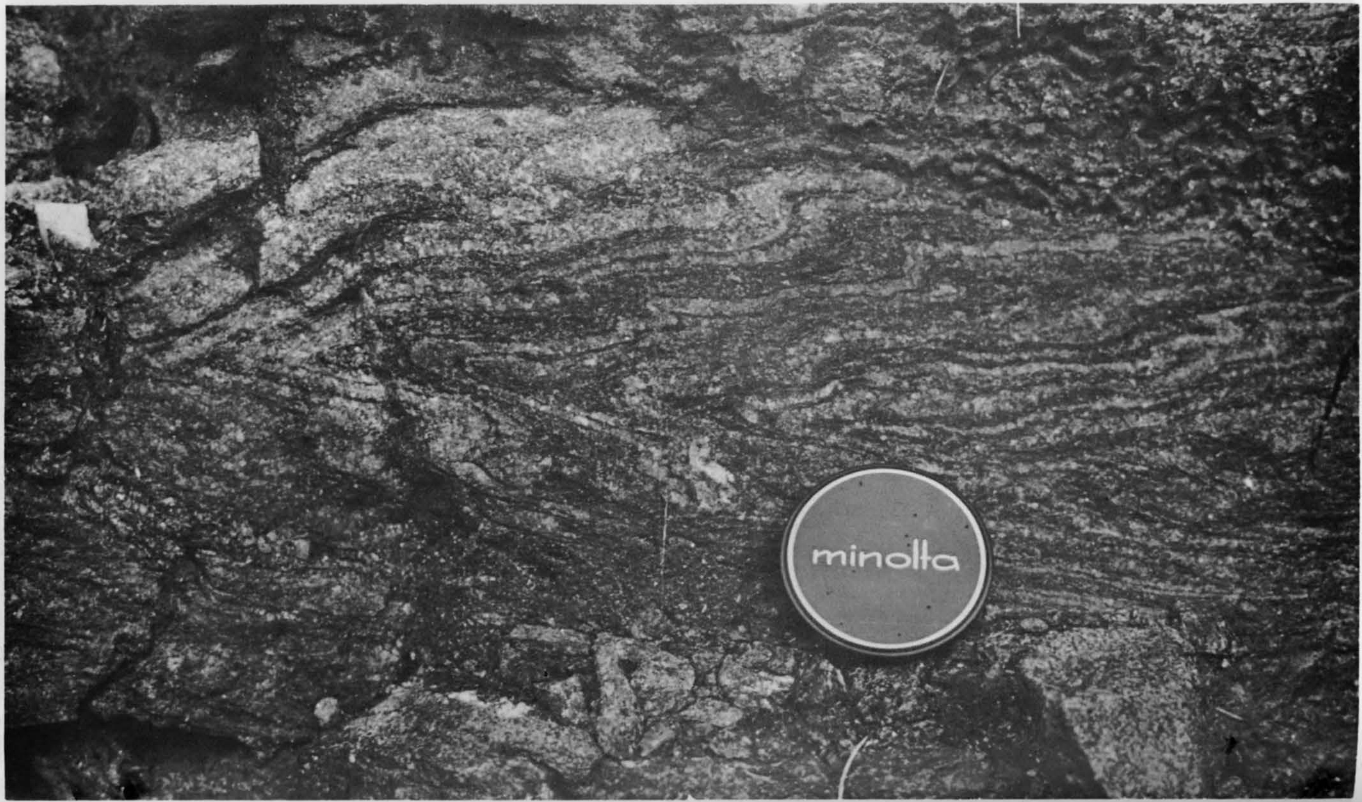

Figure 15B. Passive flow folds in the same unit at the above locality.

Figure 16. Flexural flow fold in Migmetitic Biotite Gneiss at Woodall Shoals on the Chattooga River.

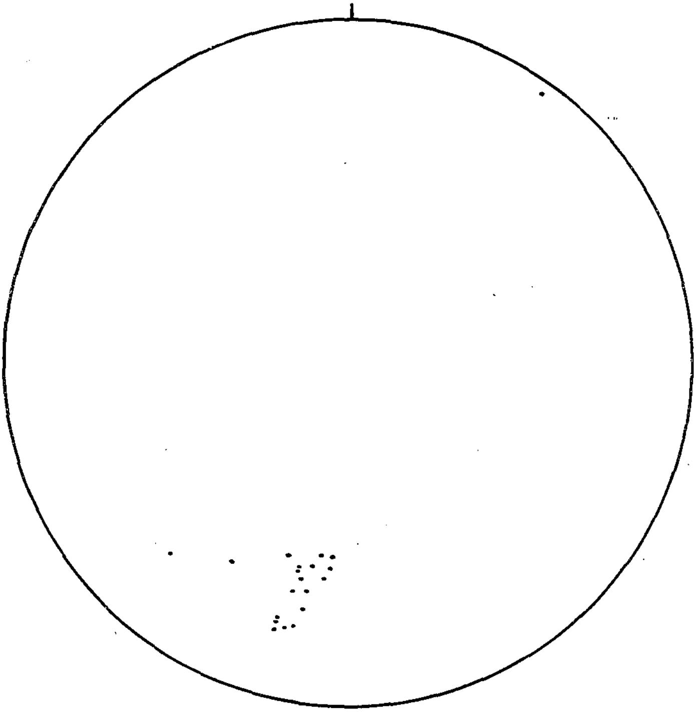

Figure 17. Point diagram of 20 slip cleavage measurement from the Blue Ridge of Rabun and Habersham Counties.

METAMORPHISM

At least three metamorphic events, the first probably Precambrian (M_1) and the other two Paleozoic (M_2 and M_3), are thought to be recorded in the rocks of Rabun and Habersham Counties, Georgia. The Blue Ridge and mobilized Inner Piedmont rocks have been raised to the middle to upper parts of the amphibolite facies of regional metamorphism, probably during the widespread mid-Paleozoic metamorphism (M_2) in this region (Hadley, 1964; McKniff, 1967; Hatcher, 1969; Rankin, *et al.*, 1969; Overstreet, 1970; Hurst, 1970). Remnant Precambrian sillimanite grade metamorphism (M_1) and granitization may have Paleozoic metamorphism overprinted onto it in some of the basement rocks of the Blue Ridge of this area. However, there are equally sufficient reasons for concluding that the Blue Ridge sillimanite (observed by Giles, 1966) and granitization is due to the later metamorphism as well. However, there are earlier granitic rocks in this area which are a part of the basement complex and have been subjected to at least one, and perhaps two, regional metamorphic episodes. Rocks of the mobilized Inner Piedmont contain abundant sillimanite.

The southeastern flank of the Blue Ridge in this area adjacent to the Brevard Zone is thought to be within the garnet isograd. This lower rank is not believed to be due to retrogression of a higher grade as the Brevard Zone is approached but is thought to be a lower grade of progressive regional metamorphism. The same decrease in metamorphic grade has been noted in South Carolina northwest of the Brevard Zone. In thin section the garnets are fresh, and other sensitive rock minerals, such as biotite, appear unaltered. The Low Rank Belt, which is not well exposed in Habersham County, is a belt of lower grade rocks that have also not been retrograded but raised by progressive metamorphism no higher than the greenschist-amphibolite transition facies (defined by Turner, 1968) or the lowermost protions of the amphibolite facies (garnet grade) (Hatcher, 1969; 1970a).

The Brevard Zone, thought to be the original northwest limb of the Low Rank Belt synclinorium (Hatcher, 1969; 1970a; 1970b; in press), has been retrograded by what is thought to be a Late Paleozoic (Alleghenyan) deformational event (M_3) (Hatcher, in press). Deformation probably took place at relatively high shearing and litho-

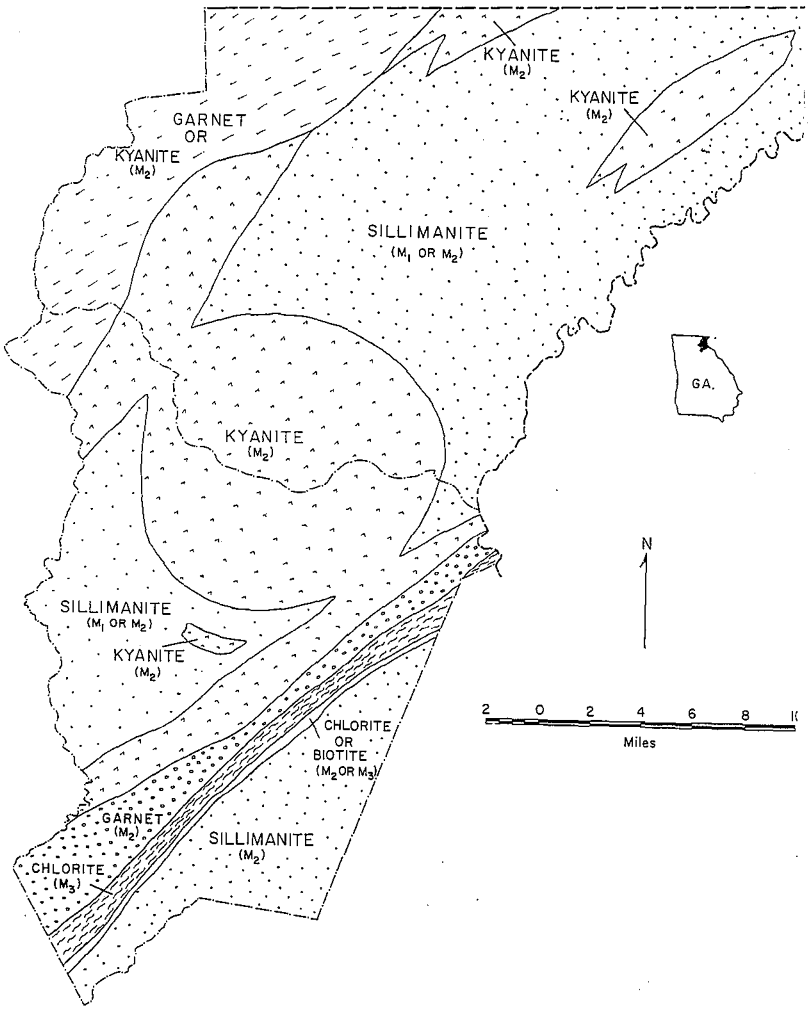

Figure 18. Map of Rabun and Habersham Counties showing the distribution of metamorphic zones. M_1 and M_2 are progressive Precambrian and Mid-Paleozoic events respectively. M_3 is the Late Paleozoic (?) retrogressive Brevard movement.

static (load) pressures but at a fairly low temperature and cataclastic metamorphism resulted. The rocks thus affected by this event were retrograded to assemblages characteristic of the greenschist facies. Thin sections of rocks from the Brevard Zone of South Carolina bear abundant evidence of the retrogressive character of this event. Garnets and biotite grains replaced by chlorite are abundantly preserved in the rocks of the Brevard Zone. Mylonites, mylonite breccias, phyllonites and other cataclastic rock types attest to the cataclastic nature of the deformation. Mylonites and phyllonites are common in the Brevard Zone of Habersham County.

Because of the abundance of metamorphosed pelitic sediments in Rabun and Habersham Counties, many occurrences of index minerals were noted throughout the two counties and a generalized map of metamorphic isograds has been prepared (Figure 18). The index minerals and isograds in this area compose a Barrovian Series similar to that originally delineated in the Scottish Highlands by Barrow, Tilley, and others (Winkler, 1967). Carpenter (1970) has concluded that a Barrovian series exists in the Blue Ridge of North Carolina. The series observed in this area is incomplete since the principal index minerals recorded for the Mid-Paleozoic event were garnet, kyanite and sillimanite.

STRATIGRAPHIC AND STRUCTURAL INTERPRETATION

Stratigraphic, Petrologic and Age Relationships

Enigma of the Tops of Beds. Graded beds in the rocks of the Tallulah Falls Formation have provided some initially contradictory data regarding the tops of beds on the crest and flanks of the Tallulah Falls Dome. As mentioned earlier, graded beds within and near the base of the Quartzite-Schist Member are upright (Figures 6 and 19). However, graded beds in the Graywacke-Schist Member are overturned on the crest of the dome. Nearly vertical or steeply northwestward dipping beds in the belt of Tallulah Falls Formation along the northwest side of the map area (Plate 1) have their tops to the northwest (Figure 20). In the belt of Tallulah Falls Formation on the southeast side of the dome in Habersham County, the relationship to tops is more obscure but from the available data, the beds appear to be upright (this belt has been folded internally where it widens to the southwest; see Plate 1). The writer has observed "reversed" graded

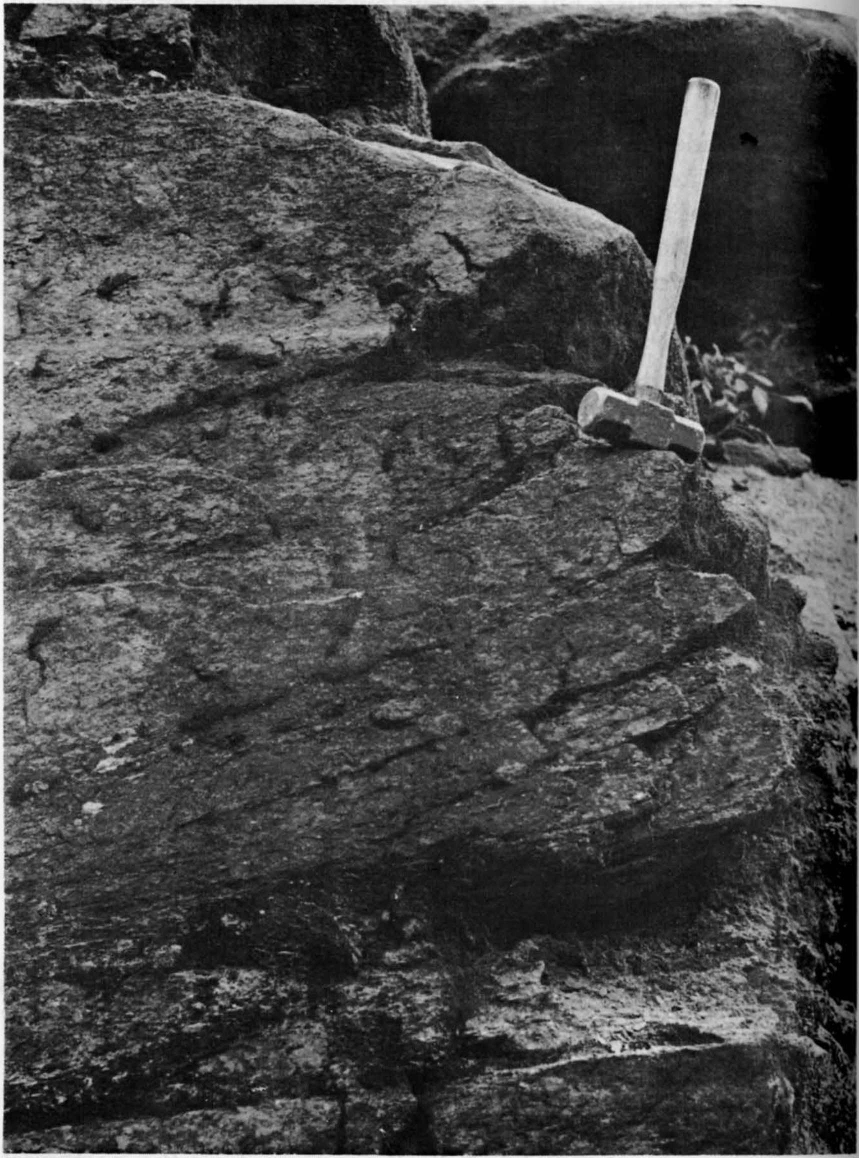

Figure 19. Thick beds of quartzite in the Quartzite-Schist Member of the Tallulah Falls Formation. These beds are graded (upright) and the curved surfaces within the bed upon which the hammer rests could be crossbeds. Located at an abandoned aggregate quarry on U. S. 441 near Wiley.

Figure 20. Nearly vertical graded beds of Tallulah Falls Formation which the tops of the beds are toward the northwest (to the right).

bedding resulting from metamorphism of normal graded beds in other areas of the Blue Ridge and is aware of its widespread occurrence in some areas, such as the Ocoee Belt of the Mineral Bluff area of North Georgia (Hurst, 1955). However, it has not been observed in Rabun and Habersham Counties.

At least two interpretations of these anomalous relationships on the crest of the dome are possible: (1) the Quartzite-Schist Member is actually upright but the tops in the Graywacke-Schist Member have been misinterpreted and this member is also upright; or (2) the tops have been correctly interpreted and the contact between these two members is actually the axial surface of a large isoclinal recumbent fold (Figure 21). The writer prefers the second interpretation at the present time. There is a considerable body of additional evidence favoring this interpretation. This will be presented in subsequent sections.

The principal stratigraphic implications of the doubly overturned sequence are as follows: (1) The Quartzite-Schist and Graywacke-Schist Members are facies equivalents. (2) The Quartzite-Schist Member is a cleaner and coarser metasedimentary unit than the Graywacke-Schist Member. If they are actually facies equivalents, the Quartzite-Schist Member is probably a shallow water deposit very close to the provenance area to the west, while the Graywacke-Schist Member is probably a deeper water facies assemblage. (3) The Garnet-Aluminous Schist Member could represent a reworked and redeposited lateritic to sublateritic soil developed on the old Earlier Precambrian erosion surface. It may not have moved a great distance in this area because the writer has observed that the amount of kyanite in this member increases where the Garnet-Aluminous Schist Member is in direct contact with the basement rocks, while kyanite is less abundant where the member is in contact with the Graywacke-Schist-Amphibolite Member. Rankin (1970) has postulated a similar origin for part of the Ashe Formation in North Carolina and Virginia. (4) The Graywacke-Schist Amphibolite Member is interpreted as a series of metavolcanics and metamorphosed deep water sediments deposited in isolated troughs that increase in number and extent to the southeast (oceanward), since the extent of this lower sequence also increases in this direction. The proposed relationships are summarized in figure 22.

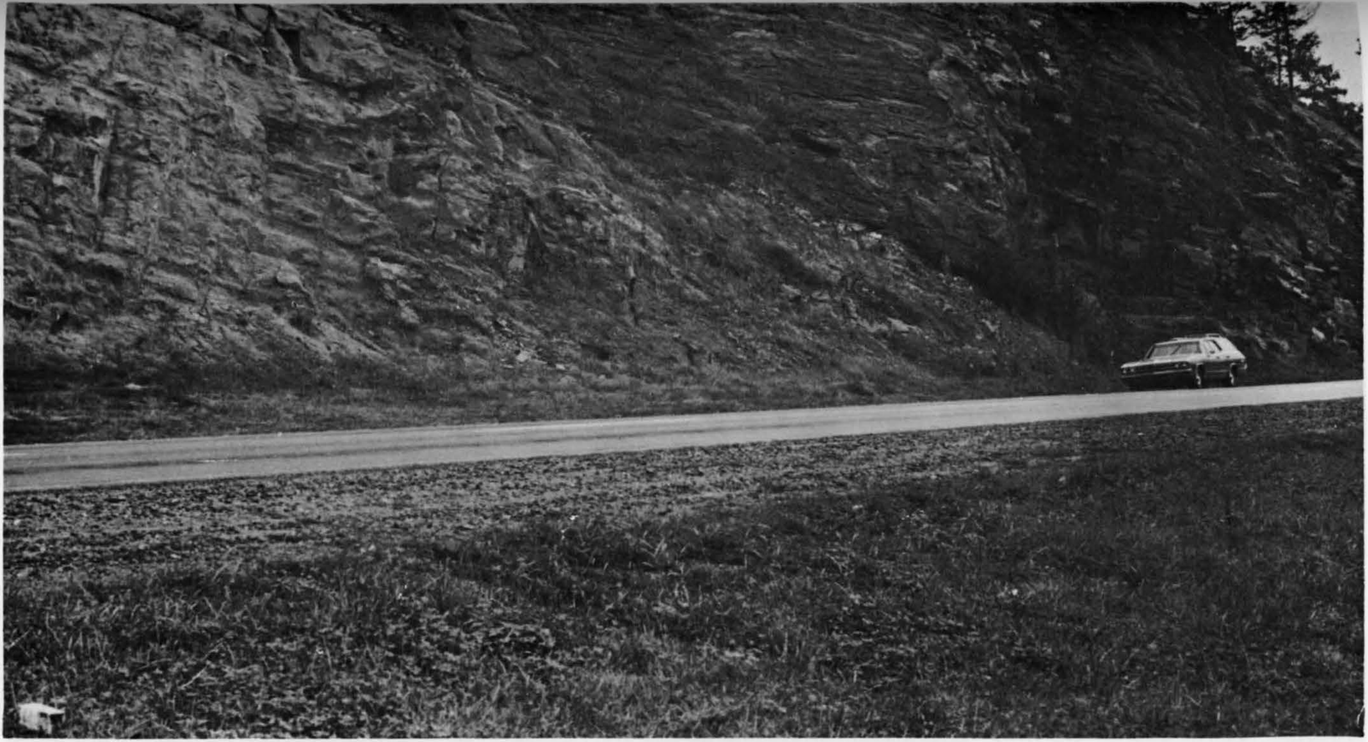

Figure 21A. Contact between the Quartzite-Schist (light colored) and the Graywacke-Schist Members of the Tallulah Falls Formation exposed on U. S. 441 southeast of Tiger.

Figure 21B. Close view of the contact.

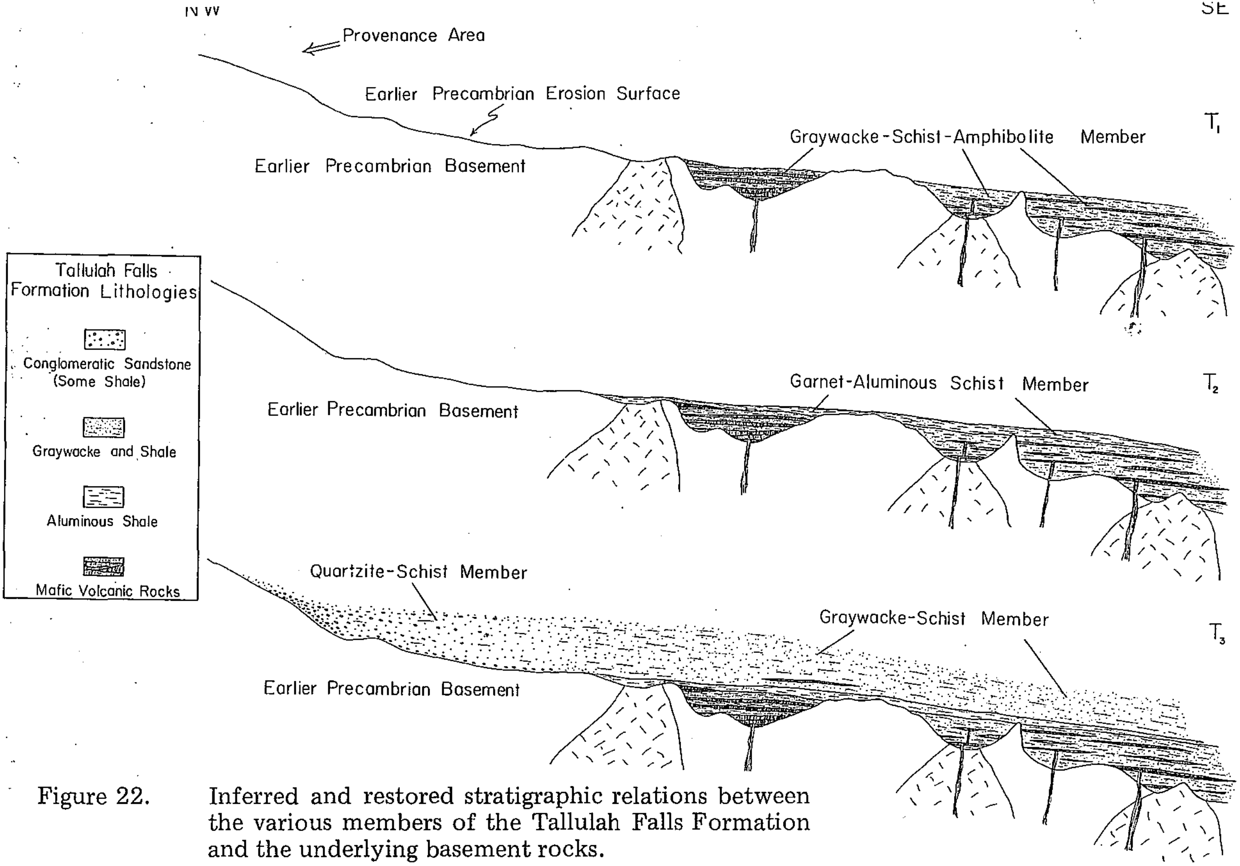

Figure 22. Inferred and restored stratigraphic relations between the various members of the Tallulah Falls Formation and the underlying basement rocks.

Early Precambrian-Later Precambrian Nonconformity. The contact between the biotite Gneiss and Granitic Gneiss units and the Tallulah Falls Formation is interpreted as a nonconformity. Several lines of evidence favor this interpretation:

1. The abrupt cessation of granitization at the contact between the Biotite Gneiss and Tallulah Falls Formation.
2. Absence of syntectonic pegmatites and rarity of any pegmatites in the Tallulah Falls Formation, in contrast to underlying rocks.
3. Truncation of granitic gneiss bodies by the Tallulah Falls Formation-Basement contact.
4. Sporadic occurrence of Graywacke-Schist-Amphibolite Member rocks to the northwest and more persistent occurrence to the southeast could be interpreted as a seaward-sloping erosion surface with an irregular topography.
5. The regularity and persistence of the Garnet-Aluminous Schist Member of the Tallulah Falls Formation rules out the possibility that this is an igneous intrusive contact. The petrologic suite present in the basement rocks would also rule this out.
6. The relationship between the amount of kyanite in the Garnet-Aluminous Schist Member and the unit that underlies this contact favors the interpretation of this contact as an erosional unconformity.

The favored interpretation of these data is that the contact between the Tallulah Falls Formation and the Biotite Gneiss and Granitic Gneiss units is a nonconformity. This interpretation is accompanied by the requisite that the nonconformity be overturned on the flanks of the Tallulah Falls Dome. This is consistent with the overturning of the Graywacke-Schist Member on the dome also.

If the reader accepts the hypothesis that the Tallulah Falls Formation-Biotite Gneiss and Granitic Gneiss contact is a nonconformity, then the Granitic Gneiss unit must be of earlier Precambrian age, and the granitization of these rocks might also be earlier Precambrian. Therefore, a very intense metamorphic event older than the Paleozoic may have been discerned in this area. If so, this is probably the Grenville age (± 1000 to 1200 million years ago) event recorded in the Blue Ridge of North Carolina and Virginia (Rankin, *et al.*, 1969). However, this will best be confirmed by radiometric age dating.

The conclusion that the rocks of the Tallulah Falls Formation are Late Precambrian age places them in at least partial correlation with the Ocoee Superseries. At the present time precise correlation with any particular portion of the Ocoee is not possible.

Speculation Regarding the Structure of the Tallulah Falls Dome

Previous Interpretations. The anticlinal character of the Tallulah Falls Quartzite (earlier usage) was recognized as early as 1915 with the work of Galpin. It was interpreted as a simple dome structure by Teague and Furcron (1948). Livingston and McKniff (1967) noted the significantly different deformational character of the rocks of the Tallulah Falls Formation which dip beneath the gneisses on the flanks of the dome. They interpreted the dome as a window of a similar deformational history to that of the Grandfather Mountain Window.

Nappe Hypothesis. The following body of facts and supporting interpretations have led the writer to conclude that the Tallulah Falls Dome is a large nappe that has been arched into its present configuration by secondary folding (Plate 2). This proposed nappe is herein given the name Tallulah Falls Nappe because the Tallulah Falls Dome is central to its recognition and delineation. The evidence favoring this interpretation is as follows:

1. The Tallulah Falls Formation is upright in the center of the Tallulah Falls Dome, appears to be overturned toward the outer part of the outcrop belt, and dips beneath basement rocks on the flanks of the dome. (Except for the tops evidence, a fault contact would explain these data).
2. Belts of Tallulah Falls Formation to the northwest and southeast are upright in their respective directions of dip (Plates 1 and 2).
3. The belts of Tallulah Falls Formation to the northwest and southeast of the dome correspond to hinge and flank (root) zones of the nappe respectively. These belts would

be connected as the upright limb in a restored model of the nappe (Plate 2).

4. The tectonic slide boundary (Plates 1 and 2) on the northwest side of the map area is based upon several things, principally truncation of units along this boundary and the significant change in mobilization across this boundary in the basement gneiss. Both suggest that there is a major tectonic boundary here.
5. A case was built favoring earlier Precambrian sillimanite grade metamorphism of the basement gneisses of the Tallulah Falls Nappe. However, this high grade of metamorphism could equally have been reached prior to folding and during remobilization during the Mid-Paleozoic metamorphism. The core of the nappe should be the area of highest metamorphic grade and the core corresponds precisely to the zone of sillimanite grade metamorphism and granitization of the basement rocks. However, if one is to believe this interpretation, he must reconcile the problem of the sudden absence of granitization above the Tallulah Falls Formation-Basement contact. Perhaps there was both Precambrian and Paleozoic sillimanite grade metamorphism, but the extensive granitization was Precambrian.

One other difficulty that immediately arises with the nappe interpretation is whether there were other metasedimentary rocks in the area of the axial surface of the fold (the Quartzite-Schist Member-Graywacke-Schist Member contact on the dome) prior to folding. Since they are not there now, and no remanants of any younger group of rocks has been found to date, it may be safe to assume that they never were deposited here (Figure 21). If this speculative assumption were correct, this would be another bit of Late Precambrian-Early Paleozoic paleogeographic data for the Southern Blue Ridge.

Brevard Zone Structure

The Brevard Zone is interpreted by the writer as a Late Paleozoic thrust zone connected genetically to the Blue Ridge thrust (Hatcher, in press). This interpretation is based upon detailed mapping of the Brevard Zone in South Carolina and reconnaissance in adjacent states. This conclusion was drawn from interpretation of outcrop patterns of repeated units, origin of exotic slices in the Brevard Zone of South Carolina, and regional tectonic patterns of Late Paleozoic structure in the Blue Ridge. The present reconnaissance study has provided no information which is contrary to that interpretation. However, some evidence of earlier (Devonian) movement on the Brevard Zone is presently being accumulated (Odom and Fullagar, 1970).

Inner Piedmont Structure

The Inner Piedmont in this area is divisible into two beds: (1) the mobilized high rank Inner Piedmont; and (2) the Low Rank Belt. Very little of the Low Rank Belt is visible in Habersham County. This is interpreted as a result of the large mobilized Inner Piedmont boundary nappe having moved over the rocks of the Low Rank Belt almost to the northwest side (Plates 1 and 2). This structural boundary was first recognized simultaneously and independently in South Carolina where the Low Rank Belt is much wider (Hatcher and Griffin, 1969) Griffin (1969) and Hatcher (1969). It was then traced across South Carolina by these workers. The writer has traced this boundary across Stephens and Habersham Counties, Georgia. Due to an insufficient amount of detailed geologic data, the structure within this nappe has not been delineated in Habersham County.

The Low Rank Belt is interpreted by the writer as a synclinorium, (Hatcher, 1969; 1970b) and the portion exposed in Habersham County is the northwest limb (Plate 2). Included in the Low Rank Belt are the rocks of the Brevard Zone (Chauga River Formation and Henderson Gneiss) thought to be equivalent to rocks to the southeast within the Low Rank Belt (Poor Mountain Formation and Henderson Gneiss).

PROPOSED CHRONOLOGY OF EVENTS FOR RABUN AND HABERSHAM COUNTIES

1. Deposition of sediments of the Biotite Gneiss units.
2. Folding, metamorphism and granitic intrusion (Grenville Orogeny?),

3. Erosion.
4. Late Precambrain deposition of the Graywacke-Schist-Amphibolite Member of the Tallulah Falls Formation as irregular accumulations and extrusions onto the earlier Precambrian topography.
5. Possible renewed localized erosion and development of an iron-aluminum-rich saprolite. Renewed inundation and rewording of the saprolite and deposition in the marine environment.
6. Deposition of the sediments making up the Graywacke-Schist and Quartzite-Schist members of the Tallulah Falls Formation.
7. Deposition of the Chauga River and Poor Mountain Formations and Henderson Gneiss to the southeast (no erosional break has been recognized at the base of these rocks).
8. Mid-Paleozoic metamorphism and folding.
9. Later Paleozoic intrusion of granitic and ultramafic bodies.
10. Brevard thrusting (late Paleozoic-Alleghenyan ?).
11. Triassic (?) intrusion of diabase dikes.

SUMMARY OF MAJOR CONCLUSIONS

1. The Graywacke-Schist and Quartzite-Schist members of the Tallulah Falls Formation are stratigraphic equivalents. Although they appear to be in conformable sequence on the Tallulah Falls Dome, the Quartzite-Schist Member is actually upright and the Graywacke-Schist Member is overturned.

2. The contact between the Biotite Gneiss and Granitic Gneiss (Earlier Precambrian ?) and the Tallulah Falls Formation is thought to be a nonconformity.

3. The Tallulah Falls Dome is thought to be part of a large nappe, here named the Tallulah Falls Nappe, that has been arched by second generation folding. Erosion has breached the dome and exposed the lower (synclinal) limb of the nappe and the basement rocks beneath the structure.

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NOTE: The Geological Survey of Georgia has used the spelling *Alleghenyan* for the later Paleozoic period of deformation (American Geological Institute, 1960, Glossary of geology and related sciences, with supplement, 2nd ed.: Am. Geol. Inst., Washington, Supp. p.2.). However, the author wishes it known that he favors the spelling *Alleghanian*, as noted in Woodward, H.P., 1957, Chronology of Appalachian folding: Am. Assoc. Petroleum Geologists Bull., v.41, p.2312-2327, and in Rodgers, John, 1967, Chronology of tectonic movements in the Appalachian region of eastern North America: Am. Jour. Sci., v.265, p.408-427.

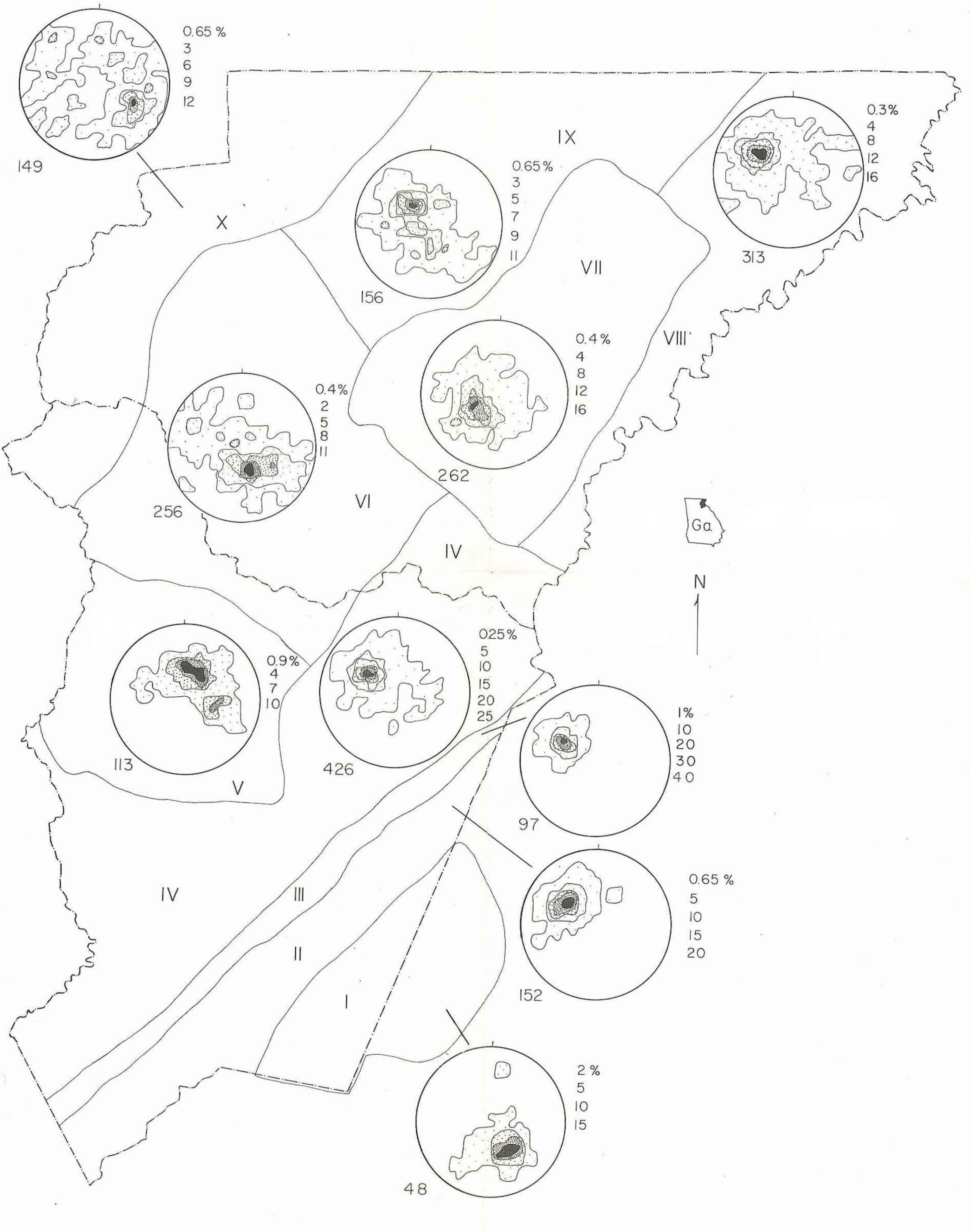
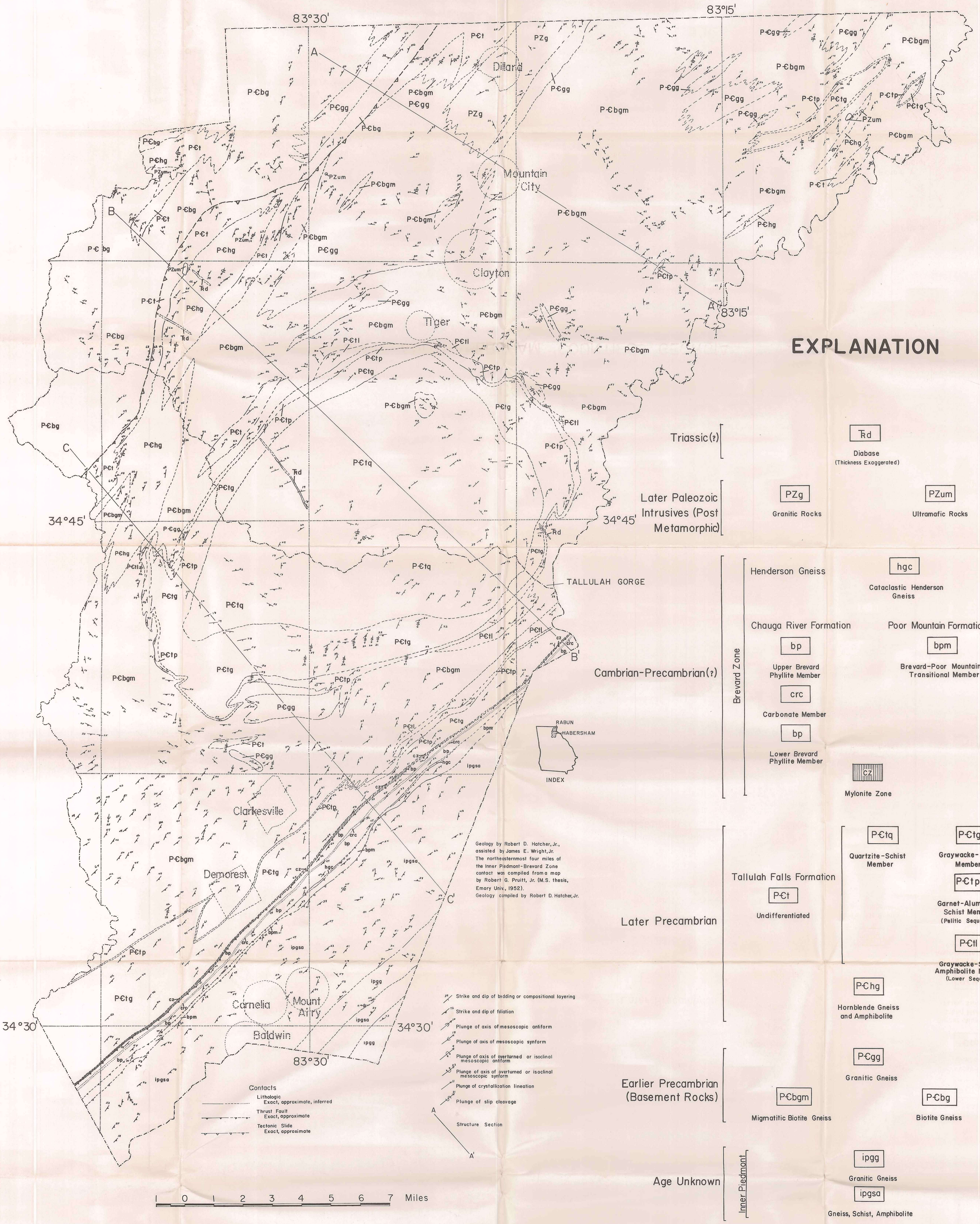


Figure 9. Contoured equal area projections of poles to foliation and compositional layering for structural subareas (numbered with Roman numerals) in Rabun and Habersham Counties. Contours (to upper right of each diagram) are in per cent per 1 per cent area. Number to the lower left of each diagram is the number of poles plotted from that subarea.

GEOLOGIC RECONNAISSANCE MAP
OF
RABUN AND HABERSHAM COUNTIES, GEORGIA

GEOLOGICAL SURVEY OF GEORGIA
BULLETIN 83

PLATE I - Hatcher



Geology by Robert D. Hatcher, Jr., assisted by James E. Wright, Jr.
The northeasternmost four miles of the Inner Piedmont-Brevard Zone contact was compiled from a map by Robert G. Pruitt, Jr. (M.S. thesis, Emory Univ., 1952).
Geology compiled by Robert D. Hatcher, Jr.

Strike and dip of bedding or compositional layering

Strike and dip of foliation

Plunge of axis of mesoscopic antiform

Plunge of axis of mesoscopic synform

Plunge of axis of overturned or isoclinal mesoscopic antiform

Plunge of axis of overturned or isoclinal mesoscopic synform

Plunge of crystallization lineation

Plunge of slip cleavage

Structure Section

Contacts

Lithologic
Exact, approximate, inferred

Thrust Fault
Exact, approximate

Tectonic Slide
Exact, approximate

EXPLANATION

Triassic(?)

- Ћd — Diabase (Thickness Exaggerated)

Later Paleozoic Intrusives (Post Metamorphic)

- PZg — Granitic Rocks
- PZum — Ultramafic Rocks

Cambrian-Precambrian(?)

Brevard Zone

Henderson Gneiss
- hgc — Cataclastic Henderson Gneiss

Chauga River Formation
- bp — Upper Brevard Phyllite Member
- crc — Carbonate Member
- bp — Lower Brevard Phyllite Member

Poor Mountain Formation
- bpm — Brevard-Poor Mountain Transitional Member

- cz — Mylonite Zone

Later Precambrian

Tallulah Falls Formation
- PЄt — Undifferentiated
- PЄtq — Quartzite-Schist Member
- PЄtg — Graywacke-Schist Member
- PЄtp — Garnet-Aluminous Schist Member (Pelitic Sequence)
- PЄtl — Graywacke-Schist-Amphibolite Member (Lower Sequence)

- PЄhg — Hornblende Gneiss and Amphibolite

Earlier Precambrian (Basement Rocks)

- PЄgg — Granitic Gneiss
- PЄbgm — Migmatitic Biotite Gneiss
- PЄbg — Biotite Gneiss

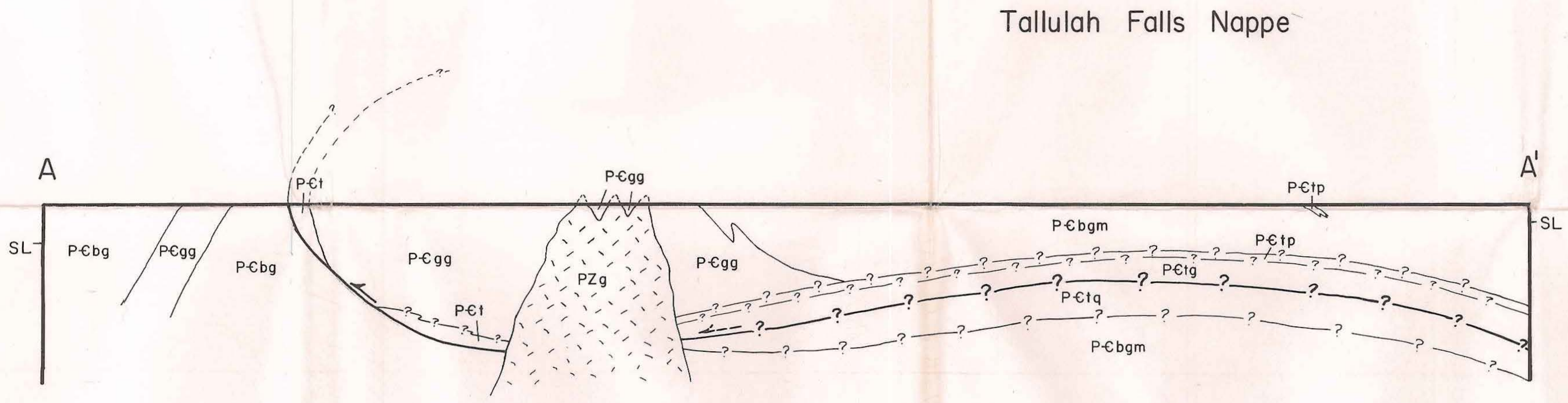
Age Unknown

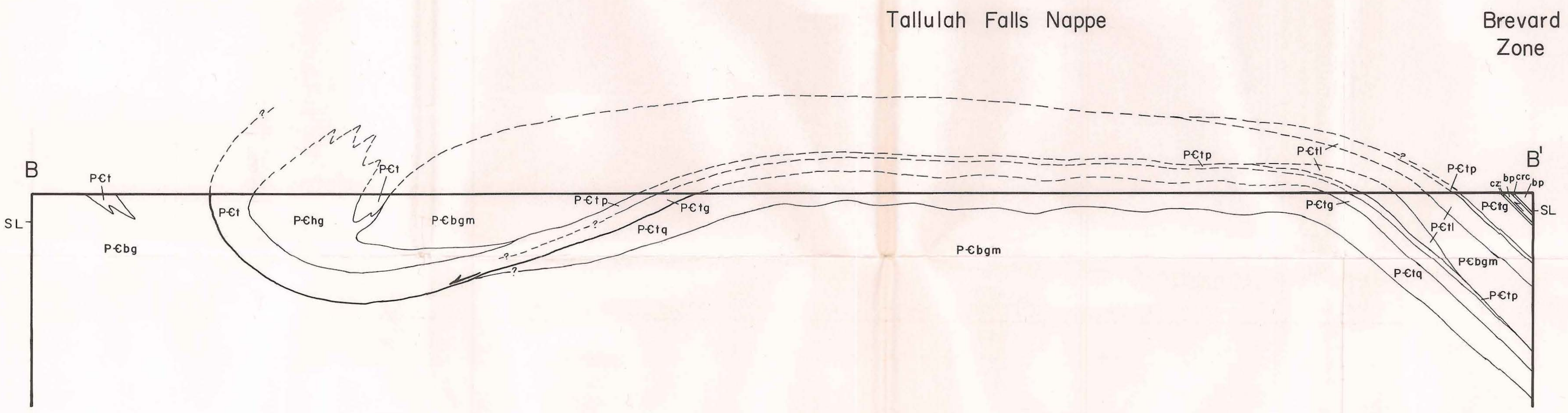
Inner Piedmont
- ipgg — Granitic Gneiss
- ipgsa — Gneiss, Schist, Amphibolite

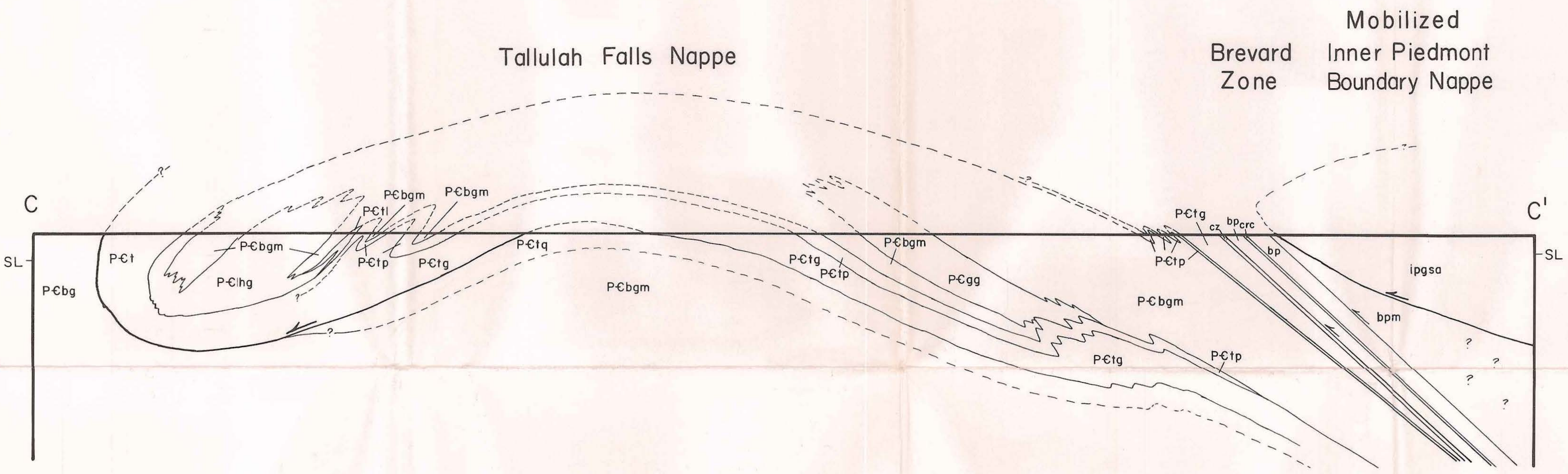
PLATE 2 - Hatcher

GEOLOGIC STRUCTURE SECTIONS

GEOLOGICAL SURVEY OF GEORGIA







No Vertical Exaggeration

See Geologic Map (Plate 1) For Explanation of Abbreviations