CAROLINA GEOLOGICAL SOCIETY

Field Trip Guidebook

Introduction to the Geology of the Eastern Blue Ridge of the Carolinas and nearby Georgia

by

Robert D. Hatcher, Jr.

Upper Whitewater Falls

October 23-24, 1976
Clayton, Georgia

CAROLINA GEOLOGICAL SOCIETY - 1976 GUIDEBOOK - HATCHER

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INTRODUCTION TO THE GEOLOGY OF THE EASTERN BLUE RIDGE OF THE CAROLINAS AND NEARBY GEORGIA

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ABSTRACT

The rocks of the eastern Blue Ridge in South Carolina, and adjacent northeast Georgia and North Carolina, consist of an older Precambrian (Grenville?) basement overlain by an assemblage of pelitic and quartzofeldspathic metasedimentary and mafic metavolcanic rocks (Tallulah Falls Formation); a higher, cleaner assemblage of pelitic and quartzofeldspathic rocks (Great Smoky Group?) containing some amphibolite; and a still younger assemblage of cleaner metasandstones, schists and felsic intrusive (?) rocks (Coweeta Group). Late Precambrian mafic, ultramafic and Paleozoic trondhjemite dikes and granitic bodies and Mesozoic diabase dikes have all been emplaced into this assemblage.

These rocks have been metamorphosed to the middle to upper parts of the amphibolite facies by regional metamorphism. None of the igneous bodies possess contact aureoles.

Several Paleozoic deformational events occurring before, during, and after regional metamorphism and subsequent erosion produced a complex outcrop pattern. A major premetamorphic fault and related east vergent structures have Been recognized and mapped along the north flank of the Coweeta syncline of North Carolina and Georgia. At least five separable sets of folds and associated structures are present. Each set of structures probably does not correspond to a separate deformational event. However, those formed under different rheological conditions must be separated in time and probably are the result of separate events.

INTRODUCTION

The 1976 Carolina Geological Society field trip will

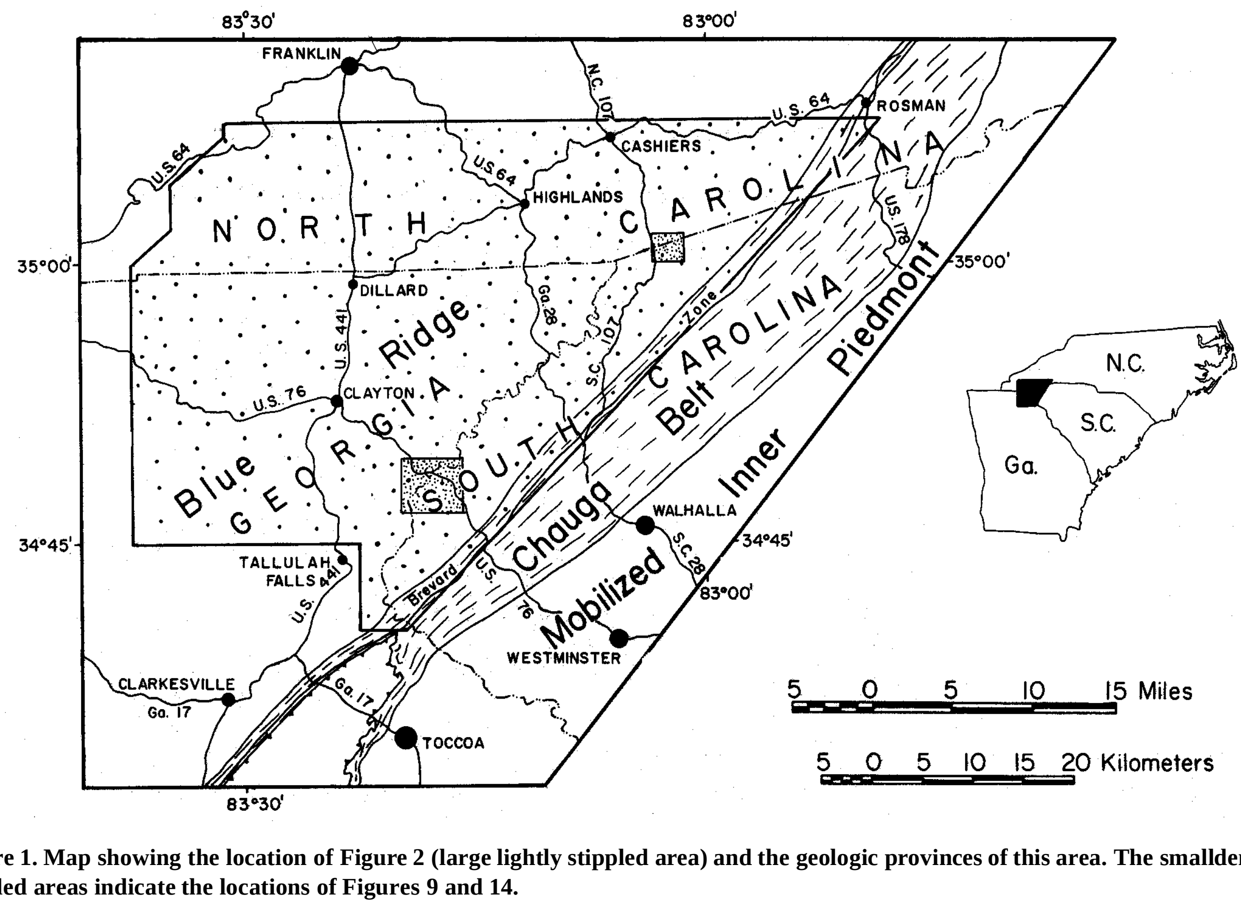


Figure 1. Map showing the location of Figure 2 (large lightly stippled area) and the geologic provinces of this area. The smalldensely stippled areas indicate the locations of Figures 9 and 14.

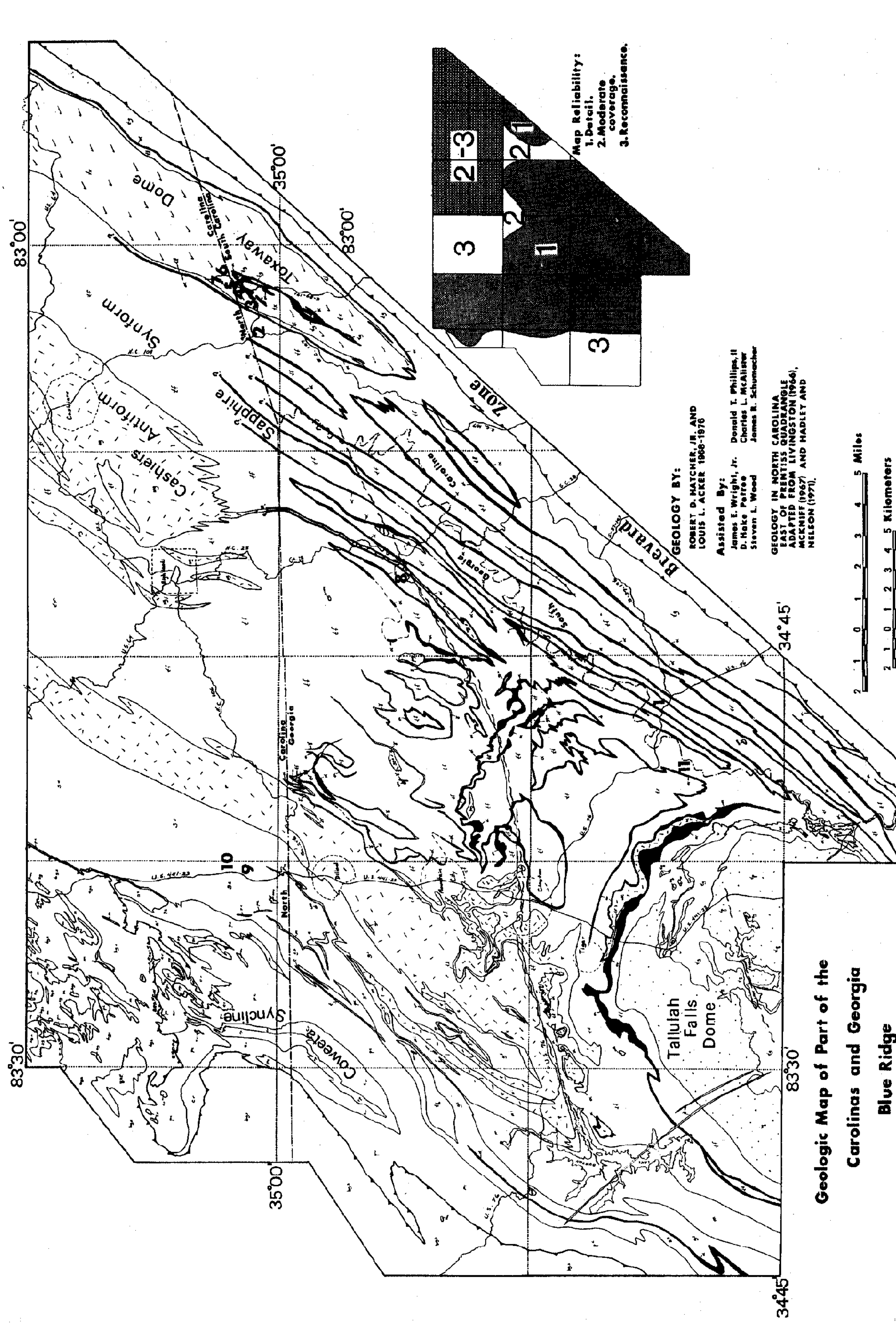
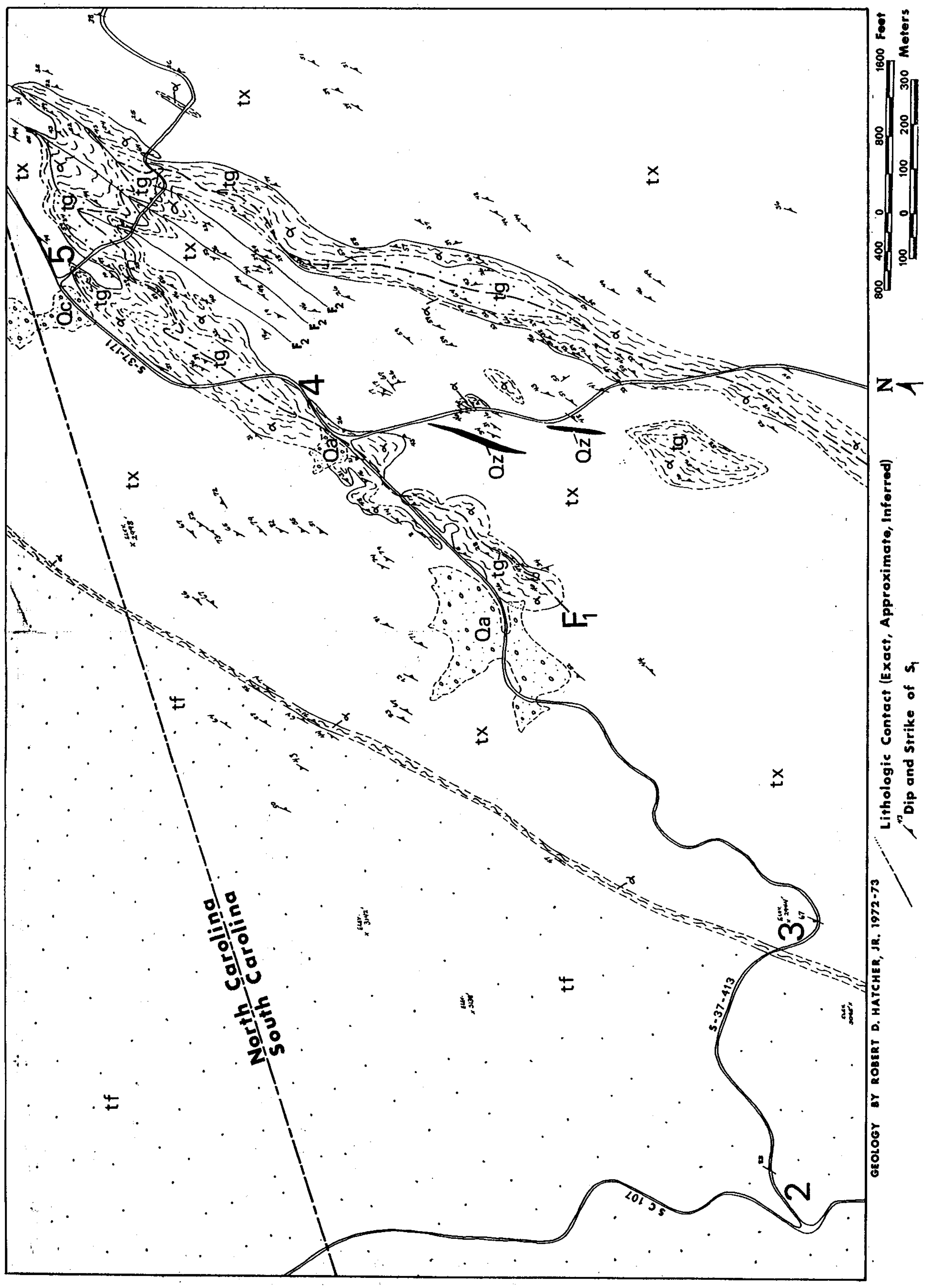

Geologic Map of Part of the Carolinas and Georgia Blue Ridge
by
Robert D. Hatcher, Jr.
1976
GEOLOGY BY:
ROBERT D. HATCHER, JR. AND LOUIS L. ACKER 1966-1976
Assisted By:
James E. Wright, Jr.
D. Hake Patree
Steven L. Wood
Donald T. Phillips, II
Charles L. McAlister
James R. Schumacher
GEOLOGY IN NORTH CAROLINA EAST OF PRENTISS QUADRANGLE ADAPTED FROM LIVINGSTON (1966), MCKNIFF (1967) AND HADLEY AND NELSON (1971).
Map Reliability:
1. Detail.
2. Moderate coverage.
3. Reconnaissance.
5 Miles
5 Kilometers
Brevard Zone
Tallulah Falls Dome
Coweeta Syncline
Cashiers Antiform
Sapphire Synform
Toxaway Dome
North Carolina
South Carolina
Georgia
83°00'
83°30'
35°00'
34°45'

FIGURE 2


North Carolina
South Carolina
GEOLOGY BY ROBERT D. HATCHER, JR. 1972-73
Lithologic Contact (Exact, Approximate, Inferred)
Dip and Strike of S_1
800 400 0 800 1600 Feet
100 0 100 200 300 Meters
N
S-37-171
S-37-413
S C 107
tx
tg
tf
Qa
Qz
Qc
F_1
F_2
2
3
4
5

EXPLANATION FOR GEOLOGIC MAP (FIGURE 2)

Igneous Rocks

d	Mesozoic diabase
t	Paleozoic (?) trondhjemite
r	Paleozoic Rabun gneiss
wc	Wolf Creek granitic gneiss (Paleozoic)
wg	Whiteside granitic gneiss (Paleozoic)
ggn	other granitic gneisses (probably Paleozoic)
peg	pegmatite (Paleozoic)
m	mafic bodies, mostly amphibolite, some metagabbro (Late Precambrian)
um	ultramafic rocks (Late Precambrian)

Migmatite

mi	Paleozoic migmatite

Stratigraphic Units

Coweeta Group (Late Precambrian-Early Paleozoic?)

rp	Ridgepole Mountain formation
cr	Coleman River formation
pc	Persimmon Creek gneiss

Great Smoky Group (?) (Late Precambrian)

gs	Great Smoky Group (?)

Tallulah Falls Formation (Late Precambrian)

tf	undifferentiated
ε	epidote bearing quartzite
λ	calc-silicate quartzite
tq	Quartzite-Schist Member
tg	Graywacke-Schist Member
α	Garnet-Aluminous Schist Member
tl	Graywacke-Schist-Amphibolite Member

Basement Rocks (Earlier Precambrian

w	Wiley Gneiss
tx	Toxaway Gneiss

Rocks North and West of Shope Branch Fault (Stratigraphic Order Unknown)

bgs	biotite gneiss and schist
sg	sillimanite gneiss and schist
qts	quartzite
pc	Persimmon Creek gneiss lithology

CONTACTS

- late (post-metamorphic) thrust faults (Brevard zone).

- pre-metamorphic faults (Shope Branch family)

- Warwoman and Lake Rabun lineaments (*not* faults)

Large numerals indicate field trip stop locations.

examine the geology of the Blue Ridge in South Carolina and a small portion of Georgia and North Carolina (Fig. 1). Its principal objective is to allow participants to observe the relationships of superimposed structures to each other, as well as the rocks in which they are developed. Representative rock units will also be seen.

The geology observed in this excursion (Fig. 2) should tie together that teen on the 1974 Georgia Geological Society and 1975 Carolina Geological Society field trips (Hatcher, 1974; Kish and others, 1975). It will also considerably revise the Blue Ridge portion of the map by Hatcher and Griffin (1969) that was part of the Geological Society guidebook for 1969 (Griffin, 1969; Hatcher, 1969).

PREVIOUS INVESTIGATIONS

The area of interest (Fig. 1), has been the subject of several studies in recent years. Livingston (1966) and McKniff (1967) completed the first modern studies in this area in which geologic mapping was carried out using 1/24,000 scale base maps and an attempt was made to relate mesoscopic structural data to the geologic maps. Roper and Dunn (1970) interpreted the geology of a portion of the South Carolina Blue Ridge. This study was also conducted along the same lines as those of Livingston and McKniff.

Earlier more generalized studies by Keith (1907a, 1907b, 1952), Teague and Furcron (1948) and Overstreet and Bell (1965) cover part or all of the present area of interest (Fig. 1). The reconnaissance study of the Knoxville two-degree sheet (Hadley and Nelson, 1971) also covers part of this study area.

Detailed geologic mapping by myself and student assistants in this area over the past several years has resulted in delineation of a stratigraphic framework for the eastern Blue Ridge of northwestern South Carolina, northeast Georgia and adjacent North Carolina (Hatcher, 1971, 1973). Refinement of the stratigraphy permitted better delineation of basement and younger rocks (Hatcher, 1973, 1974).

ROCK UNITS AND STRATIGRAPHY

The rock units of this area have all been described in some detail previously (Hatcher, 1971, 1973, 1974). However, a brief description of each is appropriate and is presented below. Table 1 compares the present nomenclature with that of others who have worked in the area.

Toxaway Gneiss

The Toxaway Gneiss (McKniff, 1967; Hatcher, in preparation) may be one of the few bodies of parautochthonous basement in the eastern Blue Ridge south of the Grandfather MoUntain window. It is typically a coarse-grained banded plagioclase-microcline-quartz-biotite-(epidote-magnetite-allanite) gneiss (Fig. 3). More massive and augen varieties

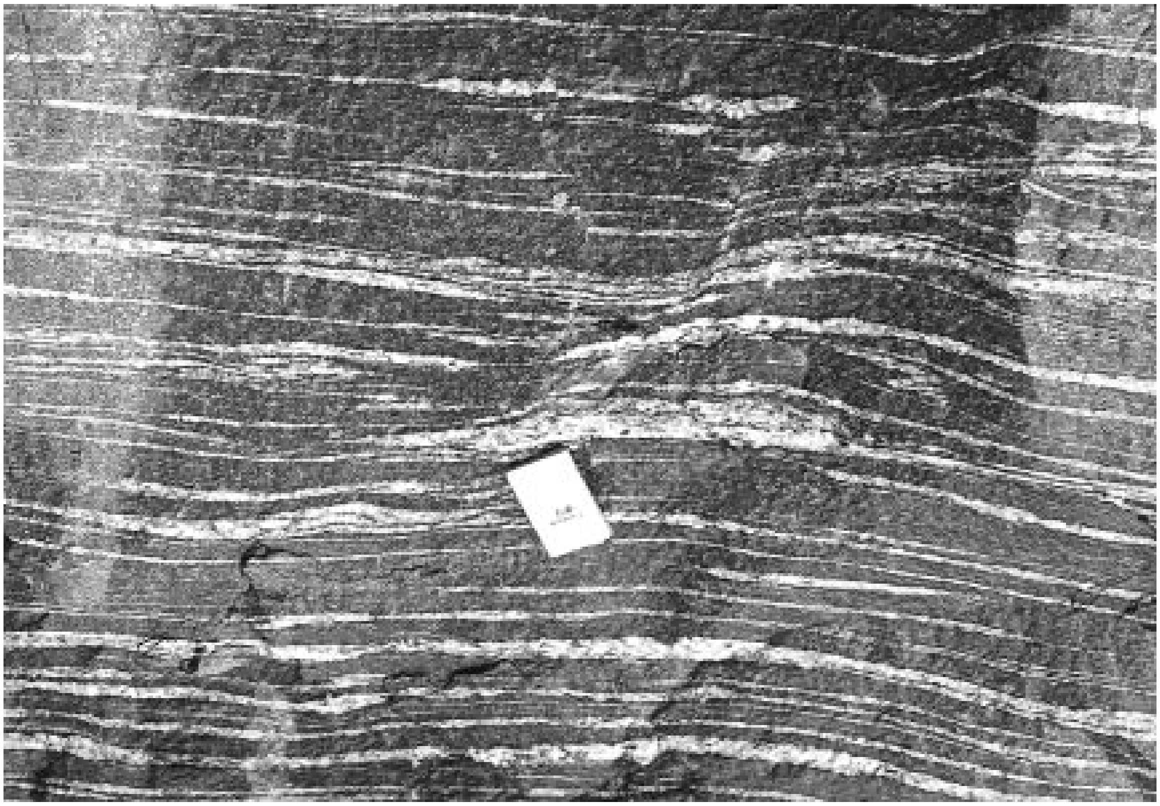


Figure 3. Typical Toxaway Gneiss. The dark bands

also occur within this unit but they appear not to be significantly different compositionally from the more typical banded type. Simple pegmatites are common within the Toxaway Gneiss.

Wiley Gneiss

The Wiley gneiss was described earlier (Hatcher, 1974) as a felsic ortho-gneiss. It is a coarse-grained microcline-plagioclase-quartz-biotite-muscovite augen gneiss. Its occurrence is restricted to the east and south flanks of the Tallulah Falls dome (Fig. 2). Preliminary data from a zircon age determination indicates the Wiley gneiss is Precambrian basement (A. L. Odom, oral commun., 1976).

Tallulah Falls Formation

The Tallulah Falls Formation (Hatcher, 1971) consists of four members: the Graywacke-Schist-Amphibolite Member (oldest), Garnet-Aluminous Schist Member, Graywacke-Schist Member and the Quartzite-Schist Member (youngest). This unit is a metamorphosed pelite-quartzofeldspathic sandstone-basalt assemblage whose youngest unit is a cleaner biotite and feldspar poor) metasandstone. The major outcrop area of the Quartzite-SchiSt Member is south of the present map area (Hatcher, 1974) but feldspathic quartzite or clean quartzite not unlike that in the main body occurs as interlayers within the Graywacke-Schist Member and as separable map units in the western part of the present map area (Fig. 2). Table 2 compares the common lithologies and mineral compositions of the different members.

Rocks of the Tallulah Falls Formation initially present themselves as a repetitious conglomeration of biotite gneiss, schists and amphibolite. However, careful study reveals that the Garnet-Aluminous Schist Member may be used as a stratigraphic marker to subdivide the unit and provide a means for deciphering the macroscopic structure. Garnets and kyanite, diagnostic components of the member, survive into the soils so that they may be traced in areas of poor exposure. Moreover, some calc-silicate quartzite (quartz-plagioclase-epidote-hornblende-garnet) layers likewise serve as markers within the Graywacke-Schist-Amphibolite and Graywacke-Schist Members in some areas (Fig. 2). A more epidote-rich quartzite is traceable over a portion of the western part of the map area.

Relations between the various members of the Tallulah Falls Formation and the underlying basement of Toxaway Gneiss and Wiley Gneiss suggest that substantial relief existed on the old erosion surface. Around the flanks of the Toxaway and Tallulah Falls domes the basal Graywacke-Schist-Amphibolite Member is present; in the central parts of these present-day domes the lower member of the Tallulah Falls Formation is missing (Fig. 4). The interpretation

Table 1. Comparisons of names and subdivisions of rock units.

Keith (1907, 1952)	Teague and Gurcron (1948)	Overstreet and Bell (1965)	Livingston (1966)	McKniff (1967)	Roper and Dunn (1970)	Hadley and Nelson (1971)	Present Usage
Whiteside Granite	Granite, locally porphyritic	Not represented	Not represented	Cashiers gneiss, Sapphire gneiss	Not represented	Porphyroblastic Granitic Gneiss, Whiteside Granite, Granitic Gneiss	Whiteside Granite, Cashiers gneiss Rabun gneiss
Whiteside Ganite, Carolina Gneiss, Roan Gneiss	Biotite and Muscovite Gneisses and Schists	Not represented	Not represented	Not represented	Not represented	Hornblende-Biotite gneiss, Biotite Schist and Geniss	Coweeta group
Carolina Gneiss, Roan Gneiss	Biotite and Muscovite Gneisses and schists, Hornblende gneiss and schist, Kyanite-Mica-Garnetiferous Schist and Gneiss, Tallulah Falls Quartzite	Biotite Schist and Biotite Gneiss, Hornblende Schist and Hornblende Gneiss	Micaceous Schist and Amphibolite	Micaceous Gneiss and Schist, Hornblende Gneiss and Schist, Kyanite Mica Schist	Mica Schist and Gneiss, Fine Grained Gray Mica Gneiss, Kyanite Mica Schist	Biotite Schist and Gneiss	Tallulah Falls Formation UNCONFORMIT
Whiteside Granite	Not represented	Whiteside Granite	Whiteside Granite	Toxaway gneiss	Felsic Gneiss	Quartz-Feldspar Biotite Gneiss (Paleozoic)	Toxaway Gneiss, Wiley gneiss (Precambrian Basement)

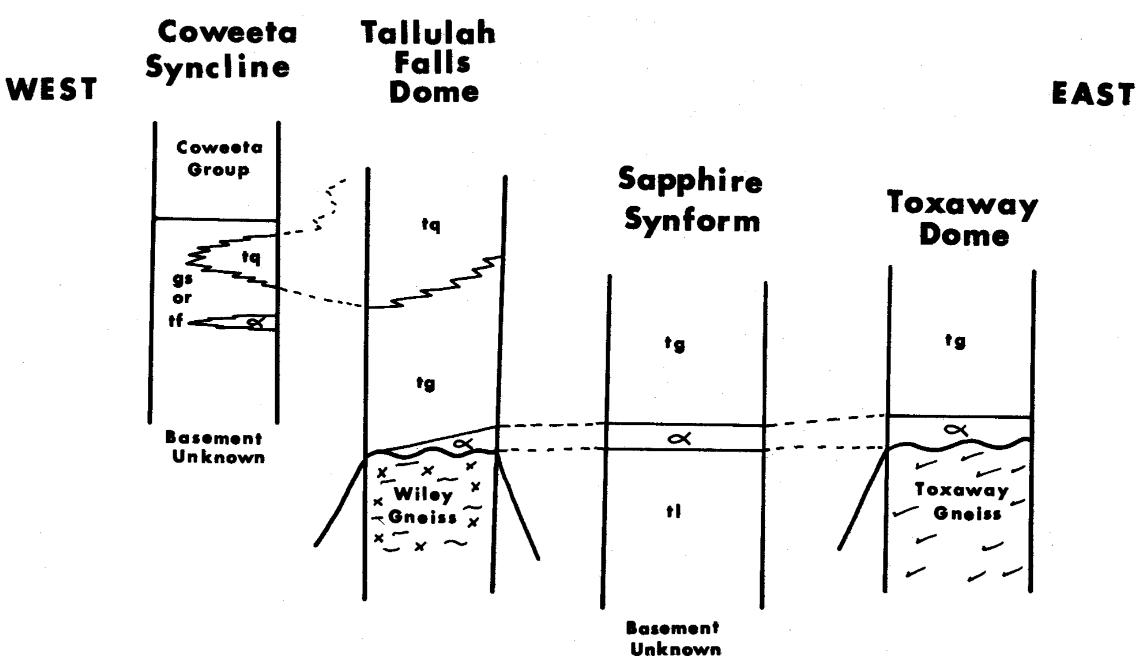


Figure 4. Possible stratigraphic relationships between rock units in the eastern Blue Ridge of South Carolina, part of North Carolina and northeast Georgia. Formation symbols are the as on Figure 2.

Table 2. Common lithologies of the Tallulah Falls Formation and their mineralogies

Member	Lithology	Mineralogy*
Quartzite-Schist	Quartzite Schist	Q, M, P, Mi, B, C (Mt, Z, T, E) M, B, Q, P (Mt, T)
Graywacke-Schist	Metagraywacke Schist	Q, B, P, (M, Mt, S, Z, A, T, E, G) M, B, Q, P (Mt)
Garnet-Aluminous Schist	Aluminous Schist Metagraywacke Amphibolite	M, G, Q, K (or Si) P, B, (Mt) Q, B, P, M (Mt, S, Z, A, T, E, G) H, P, Q, (E, Mt, G, S, A, B)
Graywacke-Schist Amphibolite	Metagraywacke Schist Amphibolite	Q, B, P, (M, Mt, S, Z, A, T, E, G) M, B, Q, P (Mt) H, P, Q (E, Mt, G, S, A, B)

Q – Quartz
P – Plagioclase
Mi – Microcline
M – Muscovite
B – Biotite
K – Kyanite
Si – Sillimanite
S – Sphene
E – Epidote (or Clinozoisite)
Mt – Magnetite
H – Hornblende
A – Apatite
T –Tourmaline
Z – Zircon
G – Garnet

*Minerals listed in order of decreasing abundance.

adapted here is that these two areas of Grenville (?) continental crust served as topographic highs during the Late Precambrian when the Tallulah Falls Formation sediments were being deposited.

The west-dipping belt of rocks west of the Rabun gneiss in Georgia and North Carolina was previously mapped as Tallulah Falls Formation (Hatcher, 1974, Figure 2). However, Hadley and Nelson (1971) mapped this as muscovite schist and gneiss. This assemblage appears to be cleaner (more quartz-rich) and does not contain the aluminous schists in North Carolina or in the Dillard Quadrangle, Georgia, but an aluminous schist (staurolite?-bearing) was mapped farther southwest in the same belt (see Hatcher, 1974, Figure 2). Moreover, the unit is not easily divisible into an upper amphibolite-poor member and a lower amphibolite-rich phase. Amphibolite does occur in this unit but is mappable as a few distinct layers (dikes or sills). Hadley (1970, Figure 1.) shows this belt as belonging to the Great Smoky Group of the Ocoee Series. It is otherwise not distinctly different from the Tallulah Falls Formation but has been separated as Great Smoky Group (?) in the present compilation (Figure 2).

Coweeta Group

The Coweeta group (Hatcher, 1974), divided into three formations, overlies the rocks of the Great Smoky Group(?) west of the Rabun gneiss belt (Fig. 2). Except for the lowest formation, these rocks comprise a still cleaner assemblage of metasandstones, quartzites, metaconglomerate (?) and muscovite and biotite schist.

The rocks of the Coweeta group are distinctly different from those below. They are more quartz-rich and contain some unique lithologies, such as pin-striped metasandstone and possible metaconglomerate in some areas. A more complete discussion appears in Hatcher (1974). These rocks will not be seen on this excursion.

Paragneisses and Related Rocks North of the Shope Branch Fault

The rocks to the north of the Shope Branch fault consist of biotite gneiss, muscovite and biotite schist and amphibolite not unlike those of the Tallulah Falls Formation, But there is also a separable coarse-grained quartz-feldspar-garnet-sillimanite gneiss present which is interlayered with biotite gneiss and schist (Fig. 2). A few bodies similar to the Persimmon Creek gneiss lithology of the Coweeta group are also present here. These rocks may be high grade equivalents of some of the others or they may be part of an entirely different unit.

A massive quartzite is also present in this area (Fig. 2). It is a medium-to coarse-grained clean quartzite similar to that of the Quartzite-Schist Member of the Tallulah Falls Formation. Its stratigraphic position is similar to the latter as well.

The differences in lithologies north and south of the Shope Branch fault may result from telescoping of lithologies and metamorphic isograds by thrusting or there may simply be a steeper metamorphic gradient present· However, the sillimanite-bearing rocks in the area north of the fault are sufficiently different that either another major rock unit is recognizable within this area or there is a major facies change to the north within the Tallulah Falls Formation. I favor the latter possibility at the present time.

Discussion

The stratigraphic sequence South of the Shope Branch fault (Fig. 2) is one of a plutonic basement overlain by an assemblage of impure sandstones and shales succeeded by two sequences of successively cleaner clastics.

The possibility that the belt of rocks west of the Rabun gneiss (Fig. 2) is Great Smoky raises several interesting possibilities. If Hadley (1970) is correct, the Tallulah Falls Formation could be an older unit and part of the earlier basement assemblage (Hadley, 1970; Hadley and Nelson, 1971). Or, the Tallulah Falls Formation could be equivalent to a lower portion of the Ocoee Series, such as the Snowbird Group.

The Coweeta group overlies the Great Smoky (?) rocks in this area, while farther west the Great Smoky is overlain by the rocks of the Murphy belt. This possibility of equivalence of the Coweeta and the Murphy rocks was discussed previously (Hatcher, 1974).

Further speculation could be made about the ages of these sequences. Assuming an age of 1000 to 1100 m. y. for the Toxaway and Wiley gneisses, the Tallulah Falls Formation may have been deposited during the late Pre-cambrian. The Great Smoky (?) rocks would also be late Precambrian and the Coweeta group rocks could be either late Precambrian or early Paleozoic. The minimum age for these rocks is the age of metamorphism, which is 450-480 m. y. (Butler, 1972; Dallmeyer, 1975). Therefore some of them could be as young as late Cambrian.

Igneous Rocks

Ultramafic and Related Rocks

Ultramafic rocks occur in two settings in this portion of the Blue Ridge. They occur as isolated dunite or peridotite bodies within the major rock units discussed above, and in association with large metagabbro-metadiabase complexes (Figure 2). Most of the ultramafic rocks are altered to a greater or lesser degree to talc, chlorite, anthophyllite, and/or serpentine bearing rocks. Alteration hydration haloes are present on several bodies, while others contain no unaltered peridotite.

The mafic rocks associated with some of these bodies in some cases still contain very coarse mafic plagioclase (labradorite-bytownite) and relict pyroxene. Most are amphibolite and amphibole gneisses, however.

All the ultramafic bodies are foliated and are probably pre-metamorphic. Therefore they are probably late Precambrian or earliest Paleozoic.

Granitic Rocks

Granitic rocks of this area may be grouped according to size into large and small bodies. All the larger bodies were referred to as Rabun gneiss (Hatcher, 1974) and coarse-grained and fine-grained phases were defined. However, the preference of this geologist at this time is to restrict the ter Rabun gneiss to the coarse porphyroblastic plagioclase-microcline-quartz-biotite gneiss forming the major belt between Clayton, Georgia, and the Tuckasegee River in North Carolina (Fig. 2 and also see Hadley and Nelson, 1971, porphyroblastic granitic gneiss unit). The fine-to medium-grained quartz diorite gneiss near Cashiers, North Carolina, which includes the original Whiteside Granite of Keith (1907), should be called Whiteside Granite (or Whiteside Granite Gneiss) and the name restricted to that body. Other similar bodies of fine-to coarse-grained granitic gneisses should be named independently until they can be shown to be genetically related.

It is here proposed that the fine-grained granitic gneiss on the northeast and east sides of the Tallulah Falls dome be informally called the Wolf Creek gneiss (Hatcher, 1974). This was formerly called the fine-grained phase of the Rabun gneiss. Other smaller, though separable bodies of granitic gneiss are called granitic gneiss until the necessity arises to name theme.

Still smaller bodies of granitic gneiss exist throughout the higher grade portions of the area. Their composition appears similar to several larger bodies. Perhaps their occurrence in the upper kyanite and sillimanite zone is a key to their origin.

Pegmatites also occur in most of the rock units in this area. They too are much more common in zones of higher metamorphic grade in feldspathic rocks. Most pegmatites are early, probably forming near the metamorphic thermal peak. A few are crosscutting and are therefore later. All are simple pegmatites but there is some variation in composition. Some are biotite-bearing, while others contain muscovite. Moreover, either microcline or albite is dominant in most pegmatites.

Trondhjemite dikes have been described in the area west of Dillard, Georgia (Hatcher, 1974). These dikes are thin and are traceable over moderate distances (Fig. 2). They occur in North Carolina along the same northeast trend. Those examined in thin section are quartz-rich (up to 60%) with zoned plagioclase and sparse biotite as the other constituents.

Diabase

Two extensive nearly vertical dikes of diabase of probably Mesozoic age are present in the southwest part of the map area (Fig. 2). The diabase here is olivine diabase (labradorite-pyroxene-olivine) having a fine-to medium-grained ophitic texture. These are the westernmost dikes of the Appalachians south of Virginia. Their thickness ranges up to l0 m.

Table 3. Mesoscopic structural elements.

FOLDS			LINEATIONS			
Generation	Style	Orientation	Generation	Type(s)	Timing	Remarks
F_1	Isoclinal Recumbent (Ductile	EW to NE Axes Verge N to NW	L_1	Elongation	Pre- to Syn Metamorphic (Early Paleozoic)	S_1 foliation refolds an earlier foliation on basement rocks. F_1 folds lie within S_1. Shope Branch fault formed.
F_2	Upright Isoclinal to Open (Ductile	NE Axes Verge NW and SE	L_2	Intersection (S_2 X S_1)	Late-Metamorphic (Early Paleozoic)	Close to thermal peak; S_2 not developed except in schistose lithologies in tight folds. Folds S_1: F_2 folds refolded by others.
F_3	Crenulation Cleavage (Brittle)	NE Axes Verge NW	L_3	Crenulation and Intersection (S_3 X S_1)	Post-Metamorphic (Mid-Late Paleozoic ?)	Not expressed on the macroscopic scale
F_4	Upright Flexural (Brittle)	NE Axes Slight Overturning	--	--	Late Paleozoic	Coeval with latter stages of emplacement of Blue Ridge thrust sheet. Some spaced cleavage.
F_5	Upright Flexural (Brittle)	NW Axes	--	--	Late Paleozoic	

METAMORPHISM

The rocks of this region have been subjected to Barrovian metamorphism raising them to the middle to upper portions of the amphibolite facies. Butler (1972) and Dallmeyer (1975) estimated the age of metamorphism to range from 450-480 m. y. The grade of metamorphism increases rapidly westward from garnet or lower kyanite grade near the Brevard zone to sillimanite near and just west of the South Carolina-Georgia border (Hatcher, 1973, Figure 2). Farther west, though, it drops again to staurolite grade in the Coweeta syncline, then increases very rapidly again to upper kyanite and sillimanite north of the Shope Branch fault.

The distinction between lower and upper kyanite grade is based upon the appearance of abundant pegmatites and an overall migmatitic character in the Tallulah Falls Formation. Kyanite is present in both subdivisions. In some portions of the higher grade zones, no distinction between members of the Tallulah Falls Formation could be made due to migmatization and only the rock type migmatite is appropriate for these areas (Fig. 2).

No contact metamorphic effects have been noted around any of the igneous bodies. The larger granitic bodies were apparently emplaced before, during or slightly after the peak of regional metamorphism while the ambient temperatures were still high and the host rocks were still in a plastic state. The trondhjemite dikes appear to have been emplaced later into brittle fractures but no contact effects are noticeable there either, although some of the dike material does exhibit a slightly finer grained texture near the dike margins. Ultramafic bodies likewise do not exhibit any contact metamorphic effects. Most appear to have been through regional metamorphism and their alteration haloes may in part be related to regional metamorphic effects rather than autometamorphism.

STRUCTURAL FEATURES AND TECTONICS

Mesoscopic Structures

During an investigation of an area of this type many kinds of mesoscopic structural features are measured. These include lineations of several kinds, including fold axes, intersections, mineral elongations and others, and S-surfaces, including compositional layering, bedding, foliations, fold axial surfaces, fracture cleavage and occasionally joints. Table 3 summarizes and describes the various mesoscopic structures used in an analysis of this area.

Bedding, where discernible, foliation and compositional banding are parallel in most places throughout this area. Generally, much of this parallelism is due to transposition which took place during regional metamorphism and formation of the S_1 foliation. These transposed S-surfaces are also parallel to the axial surfaces of the $_1$ folds. More upright axial plane foliation may be observed in many F_2 folds, particularly those which are tight or are isoclinal folds (Fig. 5).

Crenulation cleavage is a prominent structure in mica-

Figure 5. Tight, almost isoclinal, F_2 fold at Stop 4 containing a moderately well developed axial plane foliation (S_2).

ceous layers in some areas (Fig. 6). The associated folds were at one time thought to be coeval with the F_2 or more likely the F_3 folds (Hatcher, 1974). Dabbagh (1975, p. 112) considers crenulation cleavage to be developed as part of the development of flexural flow folds (F_2 in his structural sequence). DuPuis (1975) recognized more than one episode of crenulation cleavage development on the east edge of the Murphy syncline. This is attributed to the way in which structures were developed in a convex west recess in the Murphy syncline. Early crenulations there are penetrative, while later crenulations are non-penetrative.

Crenulation cleavage is demonstrably younger than $_2$ folds in the belt of Great Smoky (?) Group rocks west of the Rabun gneiss. Here the crenulation cleavage is a structure that in places began to transpose S_1 and S_2. Moreover F_2 folds have an *eastward* vergence in this belt but the crenulation cleavage verges *west.* That the crenulation cleavage is associated with westwardly overturned folds in more quartzose or quartzofeldspathic layers leads me to the conclusion that this structure is older than the more open F_4 folds whose axial surfaces are almost always nearly vertical (Fig. 7). Yet their axial orientations are similar. F_5 flexural-slip cross folds with vertical axial surfaces may have formed with F4 folds or slightly later.

It is within the context of the above discussion that the chronology of folding as presently understood was brought to light (Table 3). Many of the field trip stops were selected with the aim of illustrating this chronology.

Macroscopic Structures

The polyphase character of this region is borne out in the macroscopic outcrop patterns of rock units (Fig.2; Hatcher, 1974, Fig. 2). Interference patterns resulting fro superimposition of younger structures with different styles and orientations onto older structures are prominent on all scales. The major structures which dominate in the macroscopic realm include the Toxaway dome, Sapphire synform, Tallulah Falls dome, Coweeta syncline, and Shope Branch fault.

The outcrop pattern immediately west of the Brevard zone is dominated by northeast-trending linear belts of rocks (delineated by on Figure 2 the Garnet-Aluminous Schist Member of the Tallulah Falls Formation) which have a moderate southeast dip. The Toxaway dome (defined by the configuration of S_1) interrupts this continuity of closely spaced bands. It too is overturned to the northwest, since it has a moderately southeast dipping axial surface and its outcrop

Figure 6. Crenulation cleavage (S_3) developed in schist in the Great Smoky Group(?) near Otto, North Carolina.

pattern is also determined by the F_2 folding event.

Farther west a more irregular outcrop pattern prevails where considerable interference between F_1 and F_2 folds occurs in a southwestward continuation of the F_2 Sapphire synfor · (In the more easterly belt F_2 folds are tighter and effectively “swamp out” the earlier folds). This domain of interference folds gives way to the northeast to a more northeast-trending outcrop pattern (Hadley and Nelson, 1971). The existence of this interference zone in northeast Georgia and nearby southernmost North Carolina may be related to the more open, later Tallulah Falls dome.

The strike returns to a dominant northeast direction from the central part of the Rabun gneiss belt westward. This is again dominance of the F_2 fold set. But here the dip of S_1 is predominantly northwest, a major aspect of the structure that is maintained for many kilometers to the northwest. Interference folds on the macroscopic scale are discernible in the eastern portion of this zone but they are not as obvious as in the zone to the southeast. Farther west, in the Coweeta syncline and north of it, there is again some dominance of early folds in the outcrop patterns.

An important set of structural features which is presently being recognized is pre- or synmetamorphic thrusts or tectonic slides. A portion of these and several splays exists in the northwest corner of the map area and is here called the Shope Branch Fault (Fig. 2). This feature cuts off rock units along the north edge of the Coweeta syncline, then forms the boundary between the muscovite schist and gneiss units of Hadley and Nelson (1971) to the northeast. It appears to be folded by F_2 folds. Other segments of this or other thrusts have been recognized by Acker (unpub. data, written commun., 1975) and Dabbagh (unpub. data, oral commun., 1976). That all these thrust segments are along strike fro one another, dip to the west and may have brought older (?) ortho- and paragneisses over younger (?) paragneiss units toward the east would lead to the conclusion that they may all be segments of the same family of structures.

Discussion

The eastern Blue Ridge of northwestern South Carolina, northeast Georgia and North Carolina is a complexly deformed region. Its structural style is a product of this complex deformational history. Yet variations in Style and intensity of deformation from place to place probably reflect changes in fundamental properties of rocks, tectonic boundaries as yet poorly understood, and perhaps buttressing by some structural features. Some of these variations probably

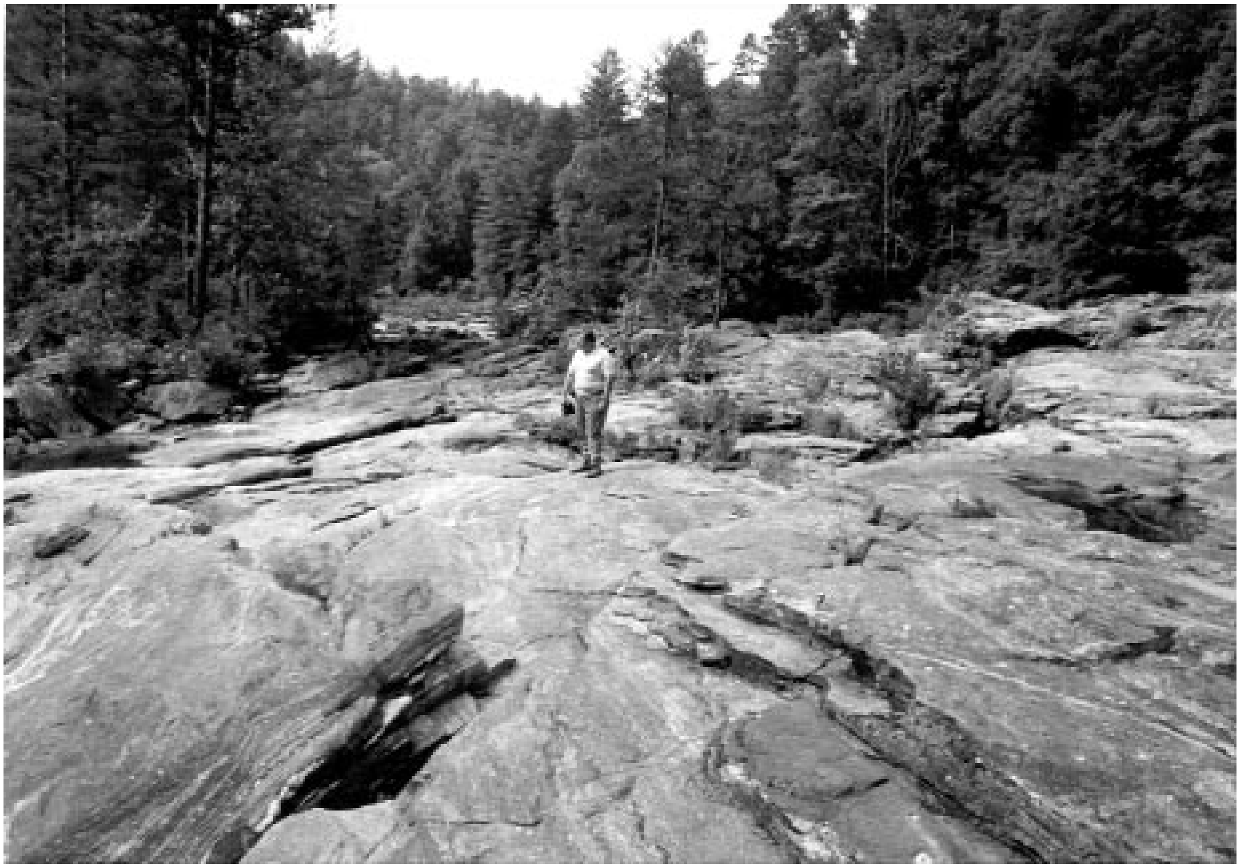


Figure 7. Dome at Woodall Shoals (Stop 11) formed by interference of F_4 and F_5 folds with nearly vertical axial surfaces.

are related to the configuration of the ancient continental margin of North America, the manner in which segments of crust, both continental and oceanic, were accreted to this ancient continental edge and to subsequent movement within the new continental block.

The present area of interest resides in a portion of one of the world's largest crystalline thrust sheets. No doubt many of the structures and patterns observed herein reflect some of the early history of movement of the thrust sheet as a thermally driven mass that finally arrived at its present position in the late Paleozoic (Hatcher, 1976).

A question which persists is whether each episode of folding in a sequence represents a separate deformational event. Or, are these structures chronologically separable, perhaps having really been formed during a single de-formational event with the different structures developing as the rheological properties of the rocks changed under the influence of the same stress field (L. S. Wiener, written commun., 1976)? There has perhaps been too much emphasis upon separating fold sets and calling each a different deformational event. Yet I feel that to say that only one stress field is responsible for all observed structures represents the other extreme. No doubt rheological properties of the rocks changed in time, as attested by the change from early structures formed in the realm of flow to later brittle structures. But the *orientation* of the stress field has also changed significantly through time. The earliest Paleozoic folds in the Blue Ridge for which orientations have been determined have an east-west axial trend (Hadley and Goldsmith, 1963 Fig. 28; Hatcher, 1974, in preparation). Later flowage and brittle folds have a northeast axial orientation, except for the F_5 cross folds, but fold vergence and dip of axial surfaces varies considerably. Some of these variations may be due to localized conditions but most are probably real over large areas of the central and eastern Blue Ridge.

It seems likely that multiple deformational events occurred in this region but changes in rheological properties were also important, as were changes in character and orientation of the stress field. The early episodes of folding (F_1 and F2) could be associated with the same deformational event. Relaxation of stresses for a period of time (millions of years?) and unloading of the mass of rocks allowed brittle structures to form in the same rocks later but during a different event.

CONCLUSIONS

1. The eastern Blue Ridge of northwestern South Carolina, northeast Georgia and adjacent North Carolina consists of an assemblage of orthogneisses (“Grenville” basement?) unconformably overlain by a sequence of metagrawacke (biotite gneiss), schists, amphibolites and metasandstones (Tallulah Falls Formation) succeeded by a cleaner assemblage of metasandstone and schists with some amphibolite (Great Smoky Group?) which is then succeeded by still cleaner metasandstones, schists and feldspathic sandstones (Coweeta group).
2. The above sequence has had emplaced into it mafic and ultramafic rocks and also intruded by syntectonic granites and pegmatites and by post-tectonic (?) trondhjemites.
3. 3.The rocks of this region have been deformed several times during the Paleozoic. Structures on all scales reflect this polyphase deformational history. Deformation may be divided into that occurring in the ductile realm (early structures) and that which occurred later in the brittle realm. Many structural features observed locally are probably related to the extended movement history of the Blue Ridge thrust sheet.

ACKNOWLEDGMENTS

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CAROLINA GEOLOGICAL SOCIETY
1976 MEETING FIELD TRIP
ROAD LOG

October 22-24, 1976

The Saturday field trip will depart at approximately 8:30 AM, depending upon the time of arrival of the buses. Departure will be from the Heart of Rabun Motel, Clayton, GeOrgia, within the Warwoman lineament (a photofault). Field trip stops are shown on the geologic map in Figure 2. Stops both days will be on the Rainy Mountain (GA-SC), Cashiers {NC-SC), Satolah {GA-SC) and Prentiss (NC) 7 1/2 minute quadrangles.
Cumulative Differential

0.0	0.0	0.0	Depart Heart of Rabun Motel south on **U. S.** 441-23-76, Ga. 2.
0.2	0.3	0.2	Grassed cut of Tallulah Falls Formation rocks.
0.3	0.5	0.1	Turn left on U. S. 76.
0.5-2.2	0.8-3.7	0.2-1.9	Cuts in migmatite and migmatitic Tallulah Falls Formation rocks grassed and covered with kudzu to varying degrees.
2.7	4.5	0.5	Kingwood Country Club
3.0-4.9	5-8.1	0.3-2.2	Cuts un migmatitic Tallulah Falls saprolite, mostly grassed.
5.0	8.3	0.1	View of Rainy Mountain (2945 ft., 906 m.) (left).
5.3-7.7	8.8-12.8	0.3-2.7	Cuts in migmatitic Tallulah Falls Formation saprolite.
7.8	13	0.1	Sillimanite schist (Garnet-Aluminous Schist Member of Tallulah Falls Formation).

7.9-8.5	13.2-14.1	0.1-0.7	Good exposures of reasonably fresh Tallulah Falls Formation biotite gneiss, muscovite and biotite schist and amphibolite.
8.6	14.3	0.1	Georgia-South Carolina state line. Chattooga River
8.7-9.2	14.5-15.3	0.1-0.6	Tallulah Falls Formation rocks and saprolite in cuts.
9.3	15.5	0.1	Garnet sillimanite schist (Garnet-Aluminous Schist Member of Tallulah Falls Formation) in cut.
9.4-9.6	15.6-16	0.1-0.3	Cuts in Tallulah Falls Formation saprolite.
9.7	16.1	0.1	**STOP 1 (15 minutes).** *Objective:* to look at the Garnet-Aluminous Schist Member of the Tallulah Falls Formation in the sillimanite zone. Exposed here are variously weathered muscovite-quartz-garnet-sillimanite schist, quartz-plagioclase-biotite metagraywacke, muscovite-biotite-quartz-plagioclase schist, feldspar-quartz-muscovite pegmatite (Fig. 14). Both the dip and strike vary due to some large mesoscopic F_2 folds. The mixed character of this rock unit is also apparent here.
9.9-10.6	16.5-17.7	0.2-0.9	Tallulah Falls Formation saprolite in cuts.
10.7	17.8	0.1	Turn left onto S-37-196, A belt of Garnet-Aluminous Schist Member rocks has been traced across U.S. 76 here.
10.8-12.6	18.0-21.1	0.1-1.9	Tallulah Falls Formation rocks and saprolites in cuts.
12.7	21.2	0.1	County road to right. Keep going straight. We are driving along the Dahlonega Plateau surface at about 1600 ft. (492 m) elevation. The hills on either side rise to the level of a higher "erosion" (2200 ft., 677 m).
12.8	21.3	0.1	County road to left (Fail Creek Road). Keep going straight.
12.9-13.6	21.5-22.7	0.1-0.8	Tallulah Falls Formation saprolite in cuts.
13.7	22.8	0.1	Garnet-Aluminous Schist Member crosses the road here (kyanite zone).
13.8-14.3	23.0-23.8	0.1-0.6	Tallulah Falls Formation rocks and saprolite in cuts.
14.3	23.8	0.0	Road turns right toward Long Creek tower.
14.3-16.4	23.8-27.0	2.1	Cuts in Tallulah Falls Formation rocks and saprolite. We are following the strike so are therefore staying in the same unit (Graywacke-Schist Member). There are good exposures of metagraywacke, schists and some of the micaceous quartzite used as a stratigraphic marker by Higgins (1966).
16.7	27.8	0.3	Four-way stop. Turn right onto S-37-193.
16.8-17.4	28.0-29.0	0.1-0.7	Saprolite of Graywacke-Schist Member of Tallulah Falls Formation in cuts.
17.5	29.2	0.2	Cross into Brevard zone and Chauga belt.
17.8	29.6	0.3	Chauga River.
17.9-18.1	29.8-30.1	0.1-0.3	Brevard phyllite member of Chauga River Formation in cuts
18.2	30.3	0.1	Cataclastic Henderson Gneiss saprolite.
18.4-18.7	30.7-31.2	0.2-0.5	Mylonite gneiss saprolite in cuts.
19.0-19.4	31.7-32.3	0.3-0.7	Brevard-Poor Mountain Transitional Member of Poor Mountain Formation.
20.1-21.3	33.5-35.5	0.7-1.9	Cuts in Poor Mountain Amphibolite saprolite.
20.9	34.8	—	S-37-290 turns right. Keep going straight.
21.4	35.7	0.1	Henderson Gneiss saprolite.
21.5	35.8	0.1	Poor Mountain Amphibolite saprolite.
21.6	36.0	0.1	S.C. 28 intersection. Turn left. Poor Mountain Amphibolite saprolite.
21.8-23.2	36.3-38.6	0.2-1.6	Poor Mountain metagraywacke, Amphibolite, and Brevard-Poor Mountain Transitional Member saprolite.

Figure 8. Intrafolial F_1 fold marked by a more quartz-rich layer in Graywacke-Schist Member of the Tallulah Falls Formation at Stop 2.

23.6	39.3	0.4	Bear right onto S.C. 107.
24.1	40.2	0.5	Brevard phyllite saprolite.
26.1-26.5	43.5-44.2	2.0-2.4	Brevard phyllite.
26.7	44.5	0.2	S-37-82 turns left. Stay on S.C. 107.
26.9-28.7	44.8-47.9	0.2-2.0	Tallulah Falls Formation rocks and saprolite. Mainly Graywacke-Schist Member.
28.8	48.0	0.1	Begin climb off Dahlonega Plateau. Still in Tallulah Falls Formation.
31.1	51.8	2.3	Burrell's Place.
32.2	53.7	1.1	Cherry Hill Campground.
32.4	54.0	0.2	Big Bend Road turns left. Stay on S. C. 107.
32.6	54.3	0.2	Moody Springs.
33.9	56.5	1.3	Burrell's Ford Road turns left. Stay on S. C. 107.
34.2	57.0	0.3	View of Piedmont to east {right). There is more than 2000 ft. (615 m) of relief here. Still in Tallulah Falls Formation rocks and saprolite. Some pegmatite is present in cuts.
35.5	59.2	1.3	S-37-325 Walhalla National Fish Hatchery road to left. Stay on S.C. 107. Some pegmatites in the Tallulah Falls Formation rocks.
36.8	61.3	1.3	Abandoned Quarry across the valley is in Toxaway Gneiss.
36.9-37.2	61.5-62.8	0.1-0.9	Cuts in Tallulah Falls Formation rocks and saprolite and some colluvium.
37.8	63.0	0.1	Turn right on S-37-413.

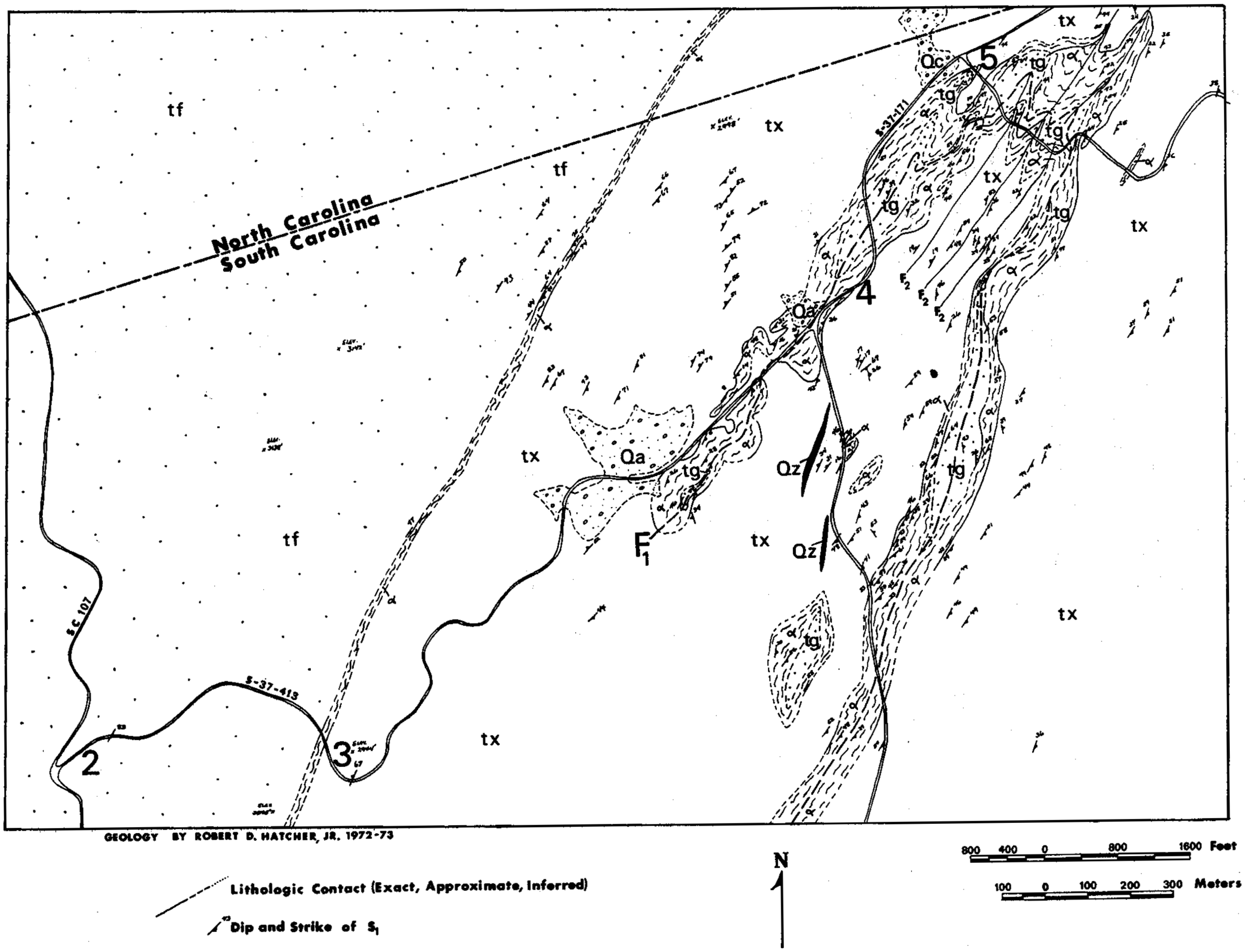

Figure 9. Detailed geologic map of part of the western edge of the Toxaway dome. Qa-alluvium. Qc-colluvium. Qz-quartz vein. Other rock unit symbols are the same as on Figure 2. Large numerals indicate field trip stop locations.

STOP 2 (20 minutes). *Objectives:* To look at some fresh metagraywacke, schists and calc-silicate. Early quartz veins and cleaner metasandstone layers have been folded into intrafolial folds whose axial surfaces are parallel to S_1 (Fig. 8). These are probably F_1 folds. S_1 is nearly vertical here (N29°E, 83°SE) Intersection L_2 lineations are prominent as well. Compositional banding is the dominant expression of S_1. The schist at the intersection is sulfidic and sulfides may be observed in the metagraywacke. Quartz veins, pegmatite and some granitic gneiss may also be observed here. Geologic map in Figure 9 will help orient you at this and the next several stops.

38.4 64.0 0.6 Garent-Aluminous Schist Member of Tallulah Falls Formation crosses the highway here. Paved road turns left. Continue on S-37-413.

38.5 64.0 0.1 Toxaway Gneiss contact.

38.7 64.5 0.2 **STOP 3 (35 min.)** *Objectives:* To look at a fresh exposure of typical Toxaway Gneiss and the contact with the Tallulah Falls Formation. All the characteristics of Toxaway Gneiss described earlier in the guidebook are present here. The alternating quartz-feldspar rich and more mafic-rich banded character is typical. Some pegmatites are present. Three may be some large (1 cm.) magnetite crystals present in the gneiss. The earliest folds here fold an older foliation. $_2$ folds verge northwest, are upright to overturned folds which in the tighter

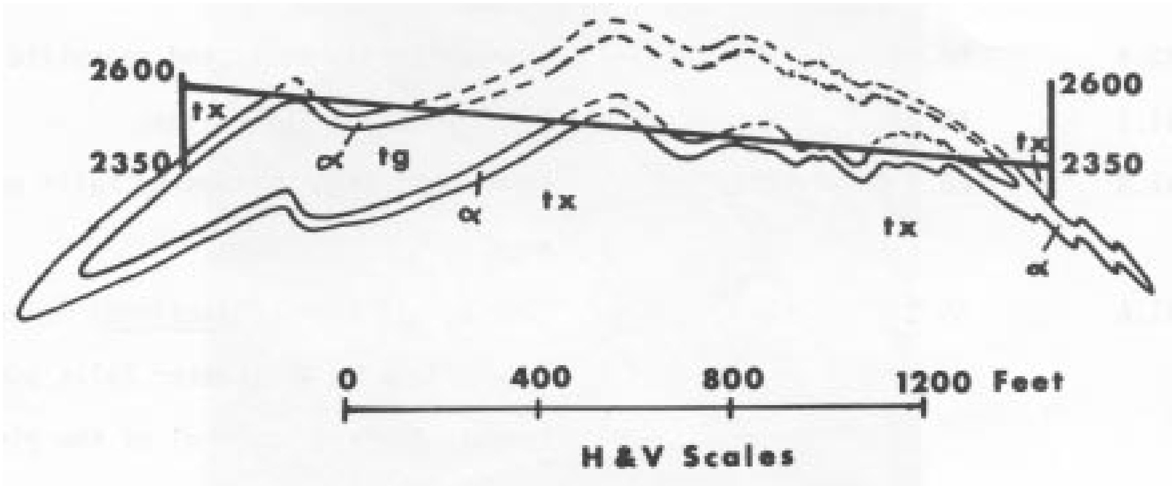

Figure 10. Cross-section sketch along road traverse in Stop 5. Rock unit symbols are the same as those used in Figure 2.

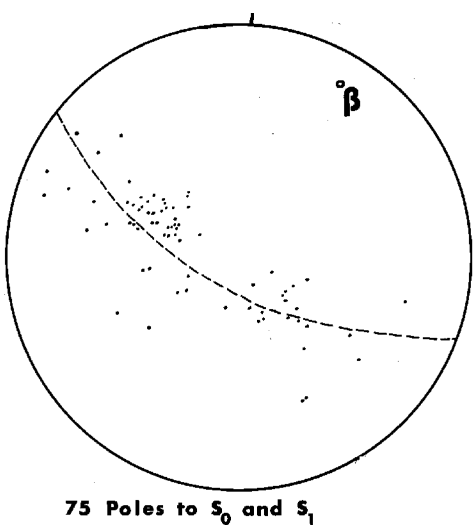

Figure 11. Lower hemisphere equal area projection of S-surface data collected along traverse in Stop 5. The value of β is N30°E, 13°NE.

Figure 12. Intrafolial F_1 folds in Toxaway Gneiss at Stop 6. Some of these refold an earlier (Precambrian? foliation).

			folds contain a poorly developed axial plane foliation (S_2) and a gently northeast plunging lineation (L_2). The S_1 foliation strikes N23°E and dips 67°NW here. We are on the west side of the Toxaway Dome. The contact with the Tallulah Falls Formation is not well exposed but the appearance of abundant garnets in the soil reflects the appearance of the Garnet-Aluminous Schist Member of the Tallulah Falls Formation. This unit rests upon the Toxaway Gneiss on the Toxaway Dome. There is an excellent view of Jocassee Reservoir, the Piedmont and the Blue Ridge front which trends almost east-west in this area. There is no fault here.
39.0-40.0	65.0-66.7	0.3-1.3	Cuts in Toxaway Gneiss rocks and saprolite.
40.1	66.8	0.1	Intersection. Turn left on S-37-171.
40.3	**67.2**	**0.2**	**STOP 4. (15 min.)** *Objectives:* To look at exposures of Toxaway Gneiss saprolite and Tallulah Falls Formation Rocks in the core of the Toxaway dome. Toxaway Gneiss saprolite exposed on the east side of the road is representative and contains several excellent F_2 folds, one of which is a tight overturned flowage fold containing a well developed S_2 foliation (Fig. 5). Weathered rocks and saprolite of the Graywacke-Schist Member and Garnet-Aluminous Schist Member of the Tallulah Falls Formation are present in the cut on the west side of the road. These rocks are badly weathered but a few blocks of muscovite-quartz-garnet-kyanite schist may be seen laying about and kyanite crystals up to 8 Cm. are present in the soil. Most are badly fractured and partly sericized These Tallulah Falls Formation rocks occur in the isolated belt of Tallulah Falls Formation in the core of the Toxaway dome and their outcrop pattern (Fig. 9) requires the dome to be interpreted as a refolded nappe.
40.4	67.3	0.1	Toxaway Gneiss saprolite and rock.
40.6	67.7	0.1	Colluvium over Toxaway Gneiss saprolite.
40.7	**67.8**	**0.1**	**STOP 5 (30 min.)** *Objectives:* To observe folding styles and lithologies across the northeast terminus of the core zone of Tallulah Falls Formation within the Toxaway dome (Fig. l0). Saprolites of all rock units involved in folding here are visible along this road traverse. As you walk along you will be able to observe each unit as it is brought up or down in very open to overturned folds. Measurement of many S-surfaces along this traverse, yields a set of values which plot on a great circle in an equal area projection and a B of N30°E, 13°NE (Fig. 11).Return to vehicles.
40.8	68.0	0.1	Toxaway Gneiss rocks and saprolite.
41.1	68.1	0.3	North Carolina State line.
41.3	69.3	0.3	Turn right into Whitewater Falls parking area ·
41.6	69.3	0.3	**STOP 6. (1 hour)** *Objectives:* To eat lunch, look at Whitewater Falls and the Toxaway Gneiss. Several of the blocks of Toxaway Gneiss along the walk to the falls contain F_1 intrafolial folds which fold an earlier Grenville (?) (F_0?) foliation (Fig. 12). Several excellent F2 folds may be seen in the old road cuts just above the falls (Fig. 13). Some of these refold earlier folds. The falls here the Upper Whitewater Falls 360 ft., 111 m.) T h e lower fa11s are downstream in South Carolina. Their combined drop is the largest east of the Rockies. Return to vehicles. Drive back to highway.
41.9	69.8	0.3	Stop and turn right.
42.1	70.2	0.2	**STOP 7 (OPTIONAL, 20 min.)** *Objectives:* To look at Toxaway Gneiss and a view of the Piedmont. F_1 and F_2 folds, typical banded Toxaway Gneiss lithology containing large magnetite crystals, and the L2 lineation may be seen here. This is an excellent fresh rock exposure. Turn vehicles around and start back south. *Note:* Geologic log will be discontinued along repetitious portions of trip.
42.4	70.7	0.2	Whitewater Falls Parking lot entrance.
43.6	72.7	1.2	Turn right onto S-37-413.
45.8	76.3	2.2	Turn left onto S.C. 107.

Figure 13. Westwardly overturned F_2 folds near Upper Whitewater Falls, North Carolina.

60.0	100.0	14.2	Turn right onto S.C. 28. Geologic lag continues from here.
60.6-60.7	101-101.2	0.6-0.7	Mylonite gneiss saprolite in the Brevard Zone.
60.8	101.3	0.1	Fresh and weathered mylonite gneiss.
61.0	101.7	0.2	Village Creek.
61.1	101.8	0.1	Brevard phyllite and mylonite.
61.7	102.8	0.6	Tallulah Falls Formation saprolite.
62.4	104.	0.7	Mountain Rest, South Carolina Post Office.
C62.6-65.0	104.3-108.3	0.2-2.6	Cuts in Tallulah Falls Formation rocks and saprolite.
65.1	108.5	0.1	Callas Gap. Tallulah Falls Formation rocks and saprolite exposed here.
65.2	108.7	0.1	View of Rabun Bald (4696ft., 1445m.), second highest mountain in Georgia to west (left).
65.2-68.3	108.6-113.9	0.1-3.3	Exposures of Tallulah Falls Formation rocks and saprolite.
68.4	114.0	0.1	Chattooga River. S.C. - Ga. State Line.
68.5-69.6	114.2-116.0	0.1-3.2	Cuts in Tallulah Falls Formation rocks and saprolite.
69.7	116.2	0.1	Amphibolite, part of the Laurel Creek mafic-ultramafic complex.
69.8-70.3	116.3-117.2	0.1-0.6	Cuts in Tallulah Falls Formation rocks and saprolite.
70.4	117.3	0.1	Cross Laurel Creek and enter Warwoman Lineament.
70.6	117.7	0.2	Pine Mountain, Georgia. Bear left on Warwoman Road toward Clayton.
70.7	117.8	0.1	Cut in Garnet-Aluminous Schist Member of Tallulah Falls Formation.

70.9	118.2	0.2	West Fork of Chattooga River.
71.3	118.8	0.4	**STOP 8 (15 min.)** *Objectives:* To look at a small mass of Whiteside Granite (quartz diorite gneiss) flanked by kyanite schist. The narrow mass of Whiteside Granite has been traced into the main body in North Carolina. Interestingly, this thin body is flanked on both sides by the Garnet-Aluminous Schist Member of the Tallulah Falls Formation. Garnets up to 2 cm occur in the schist. Kyanite is difficult to find here. Some amphibolite is present. F2 folds are also present. Did the granite find easy access into the schist? What is the shape of these granitic bodies in the eastern Blue Ridge? Are they cactoliths? This stop in Georgia should reciprocate fox, several stops by the Georgia Geological Society in South Carolina this year
75.6	126.1	4.3	Cuts in Tallulah Falls Formation rocks.
75.5	126.2	0.1	Megaboudins of amphibolite in metagraywacke and schistof Tallulah Falls Formation.
75.8-84.8	126.3-141.3	0.1-9.1	Cuts in Tallulah Falls Formation rocks and saprolite.
84.9	141.4	0.1	Heart of Rabun Motel and U.S. 441-23. Turn right. It is hard to believe that a road along a lineament could have so many curves (F_6 deformation? C. E. Mershat written commun., 1976). Must be an inherent property of photofaults.
85.1-87.3	141.8-145.5	0.2-2.4	Cuts in Tallulah Falls Formation rocks and saprolite.
87.3	145.5	—	Mountain City, Georgia.
87.9	146.5	0.6	Blue Ridge divide. Water on the north side of the divide drains to the Gulf of Mexico, that on the south drains to the Atlantic. Note also that the valley opens up to the north. Is this an older drainage?
90.0	150.0	2.1	Highest mountains to the northwest are Pickens Nose (4890 ft., 1505 m) and Ridgepole Mountain (5060 ft., 1557m). To the east is Rabun Bald.
91.2	152.0	1.2	Grassed cut in Rabun gneiss.
91.3	152.1	0.1	Dillard, Georgia, home of the Dillard House Restaurant and Motel, a real challenge if you like to eat large amount of good food.
91.6	152.7	0.3	Boulders of Rabun gneiss on left.
92.5	154.2	1.1	Ga. - 246 (N.C. 106) turns right, cuts in Great ·Smoky or Tallulah Falls rocks.
93.2	155.3	0.7	North Carolina State Line.
93.9	156.5	0.6	Cuts in Great Smoky (?)
96.0	160.0	2.1	Turn right on Road 1631.
96.1	160.1	0.1	Cross Little Tennessee River.
96.2	160.3	0.2	**STOP 9 (20 min.)** *Objectives:* To observe two generations of folds and three S-surfaces as they are developed and deform the earlier structures. Lithologies present are feldspathic metagraywacke and muscovite-biotite schist of the Great Smoky (?) Group. F_2 folds have an axial plane foliation developed and F_3 crenulation cuts the F_2 folds. Separation of fold sets and S-surfaces is easy here because the F_2 folds verge *east* while the F_3 folds are *west* vergent. Why do F_2 folds verge east in this area? This stop is located in a cut of the now dismantled Tallulah Falls Railroad. (The Walt Disney film, "The Great Locomotive Chase" was filmed on this railroad.) Return to U.S. 441-23.
96.3	160.5	0.1	Turn right on U.S. 441-23.
98.1	163.5	1.8	Turn right on Road 1636-Tessentee Road.
98.4	164.0	0.3	Road 1635 turns right. Stay of Road 1636.
98.9	164.8	0.5	**STOP 10 (30 min.)** *Objectives:* To observe three generations of folds and the fresh lithologies of the Great Smoky (?) Group. Thin to medium beds of quartz-biotite-feldspar-muscovite metasandstone are inter-bedded with muscovite-biotite schist. These rocks contain early isoclinal recumbent folds (F_1), upright east vergent folds (F2) and a crenulation cleavage

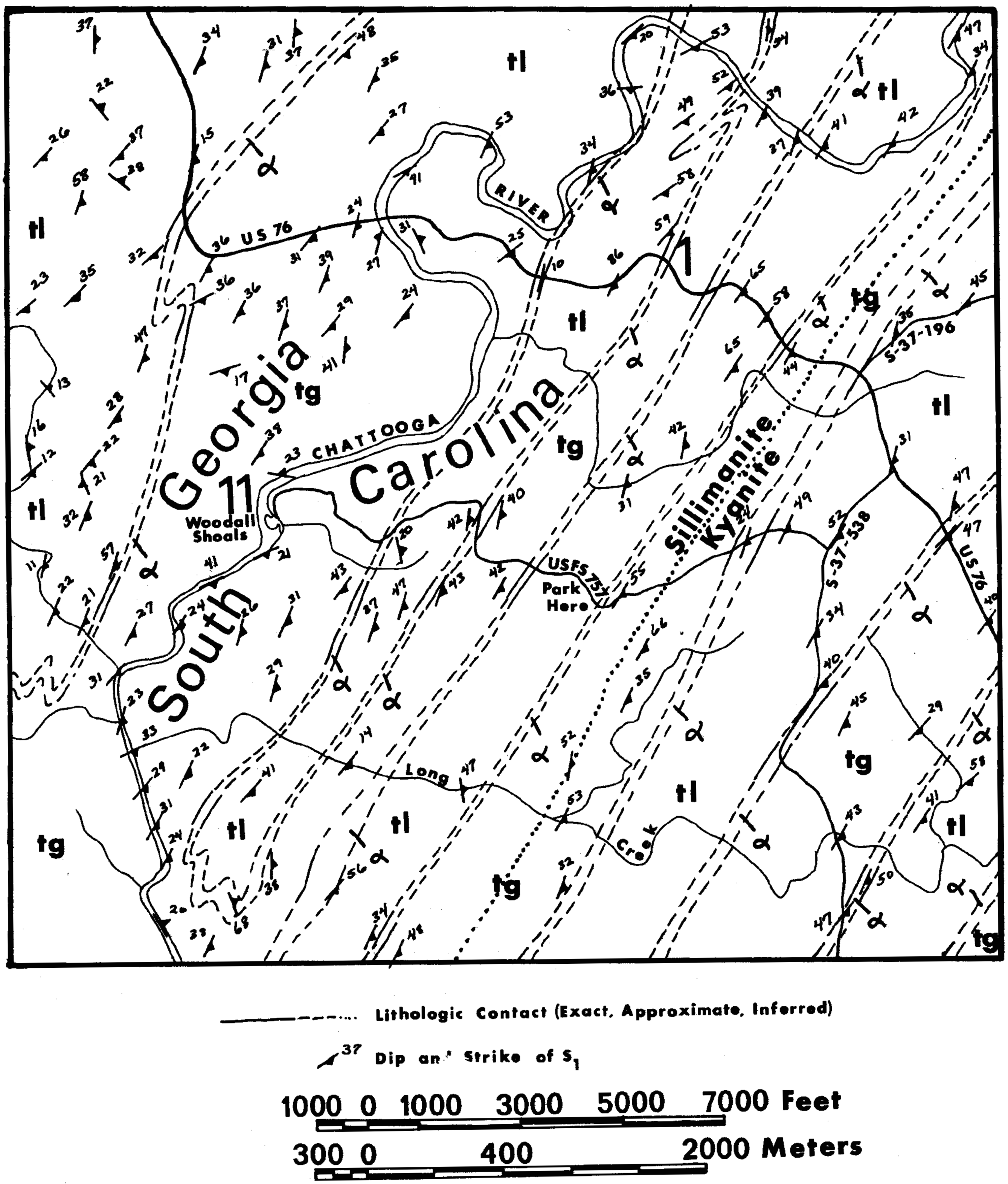

Figure 14. Detail geologic map of the area surrounding Woodall Shoals. Rock unit symbols are the same as on Figure 2. Large numerals indicate field trip stop locations.

			(S3). This is one of many such exposures of this type in this area but is by far the most accessible one. The chronology of early deformation is easily discerned here. PLEASE RESPECT THE OWNER'S FENCE AND OTHER PROPERTY. Use facilities at your own risk. Return to U.S. 441-23.
99.6	166.0	0.7	Turn left (South) on U.S. 441-23. Return to Heart of Rabun Motel.
112.6	187.7	13.0	Heart of Rabun Motel
			END OF DAY 1

ROAD LOG FOR DAY 2, CAROLINA GEOLOGICAL SOCIETY ANNUAL FIELD TRIP MEETING OCTOBER 24, 1976

0.00			Depart Heart of Rabun Motel at 8:30 A.M. Drive south on U.S. 441-23-76 Follow road log for *Day 1* along U.S. 76 to S-37-196.
10.7	17.8	10.7	S-37-196. Continue east on U.S. 76.
11.1	18.5	0.4	Turn right on S-37-538.Tallulah Falls Formation rocks and saprolite in cuts.
11.5	19.2	0.4	Turn right onto U.S. Forest Service Road 757. Woodall Shoals Road.
11.9	19.8	0.4	Garnet-Aluminous Schist Member of Tallulah Falls Formation. Contains kyanite here.
12.8	21.3	0.9	Park out of the road so that other traffic can pass. Lock your vehicle.

STOP 11 (2-3 hours). *Objectives:* To observe Tallulah Falls Formation rocks along road and the Chattooga River at Woodall Shoals. The sillimanite-kyanite isograd is located about at the field where the traverse begins. A sillimanite-bearing aluminous schist crosses the road just below the field (Fig. 14). It may be difficult to find on the road. Trace your route on the geologic map and see if you can tell which unit you are in by the rock types present. Also, keep in mind the appearances of the weathered rocks. The same biotite gneisses are exposed on the river. Do they look similar? Woodall Shoals: The hike into Woodall Shoals is -2.2 miles (~3.67 km.). Once you have arrived you will hopefully find the hike worthwhile. The lithologies present here are migmatitic biotite gneiss, some amphibolite boudins, pegmatites and a small amount of muscovite biotite schist of the Tallulah Falls Formation. These lithologies are typical of those occurring along the Chattooga and other streams in this area. Gneisses and related rocks exposed here are more resistant to mechanical weathering processes that dominate in the streams, while the schistose character of the rocks on the ridges bespeaks the resistance to chemical weathering of the schists.

There are four sets of folds present here. Early (F_l) folds have been refolded by northeast-trending F_2 folds. Here F_1 and F2 folds are not coaxial. I have never seen a crenulation cleavage here so the F_3 folds may not be represented. F_4 and F_5 folds are present as mesoscopic domes and basins (Fig. 7). The Tallulah Falls dome located just to the west may be a macroscopic analog. Woodall Shoals is the Rosetta Stone for understanding the structure of this part of the Blue Ridge. There is a N45°W spaced cleavage present in some of the rocks here which to date has no satisfactory explanation, unless it is a fracture cleavage related to the F_5 folds.

Perhaps Woodall Shoals is an appropriate place to terminate the 1976 Carolina Geological Society Field Trip. You may hike back to your cars, return to S-37-538 and turn left. If your destination is south or east (South Carolina or eastern North Carolina) you should turn right at the intersection of S-37-$28 and U.S. 76. If your destination is in East Tennessee western North Carolina or most places in Georgia, you may want to return to Clayton and start fro there.