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STRATIGRAPHY, STRUCTURE, AND PETROLOGY OF THE PIEDMONT IN CENTRAL SOUTH CAROLINA

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INTRODUCTION

The purpose of the present field trip is to illustrate some geologic problems that have been encountered in the Carolina Slate Belt and adjacent Charlotte Belt in central South Carolina. It is hoped that the trip will encourage problem oriented research in the Piedmont by students and professional geologists.

Over the past twenty years considerable geologic mapping has been accomplished in the vicinity of Columbia. This work has been mainly sponsored by the State Development Board, and by the University of South Carolina. The present map anti guidebook are largely based on personal field work by Secor and Wagener, supplemented by the references listed at the end of this guide. Although the authors have made use of the maps compiled by others, they take full responsibility for the interpretations presented here, which in some areas may conflict with the original interpretations.

The rocks in the Slate Belt near Columbia were originally deposited as a sedimentary sequence more than 15,000' thick. The lower two-thirds of this sequence was predominantly composed on waterlaid tuffaceous material ranging in composition from basaltic to rhyolitic. The upper part of the sequence was composed of thin bedded mudstones, in part of turbiditic origin. This sedimentary sequence has been intruded by a variety of thin dikes and sills, and then folded, faulted and metamorphosed to the green-schist and amphibolite facies. In late Paleozoic time a number of granitic stocks intruded the metamorphosed sediments, and in late Triassic or Jurassic time a swarm of northwest trending olivine diabase dikes were intruded. This Piedmont igneous and metamorphic complex is unconformably overlaid by Cretaceous sediments along the Fall Line near Columbia. The angular unconformity at the base of the Coastal Plain sequence slopes gently southeastward at about twenty feet per mile. Many of the hilltops are capped by erosional remnants of this Coastal Plain sequence. In most places a thick mantle of residual soil covers fresh bedrock, but this soil apparently has not been subjected to creep, and structural features such as cleavage, foliation, lineation, and minor folds can be recognized in the soil and used to interpret geologic structure. Most of the streams in the area have cut down through the soil mantle and are flowing across fresh bedrock. Although outcrops are rarely spectacular, the field control afforded by saprolite and small outcrops is generally superior to that encountered in glaciated areas such as New England.

SLATE BELT STRATIGRAPHY

Three major stratigraphic units of regional extent have been recognized in the Slate Belt near Columbia. These units are here designated the Richtex Formation, the Persimmon Fork Formation, and the Wild-horse Branch Formation, in order of increasing age. Each of these units is thousands of feet thick, however only the Persimmon Fork Formation has been observed in its entirety. The top of the Richtex Formation, as well as any younger units, have been removed by erosion from the region near Columbia, and the bottom of the Wildhorse Branch Formation, as well as any older units, have not yet been exposed by erosion. These stratigraphic units are composite in nature, and each is defined on the basis of a characteristic association of lithologic types. It is possible to subdivide these formations into members, however the members are of only local extent and have not been given formal stratigraphic names.

The Wildhorse Branch Formation was originally deposited as a sequence containing approximately 20 percent interbedded carbonaceous shale, 40 percent mafic tuff, and 40 percent felsic tuff. Mafic arnygdaloidal flows were also locally abundant. Low grade regional metamorphism has converted the original sediment types into graphitic phyllite, green-stone, and felsic tuffaceous phyllite respectively. These lithologic types characteristically occur in beds or layers1 to 10 feet in thickness, although layers much thinner and thicker than the above average are common. In some places both the greenstone and the felsic tuffaceous phyllite contain elongate fragments of graphitic phyllite that are interpreted as chips of carbonaceous mud incorporated in waterlaid tuffaceous material. The felsic tuffaceous phyllite also contains thin quartzofeldspathic lenses that are interpreted as compacted pumice lumps, Most of the tuffaceous sediment in the Wildhorse Branch Formation was deposited as poorly sorted sand-sized material, although tuff breccias containing fragments up to one foot in diameter are found locally.

When unweathered, the graphitic phyllite is medium gray in color, whereas the greenstone and felsic tuffaceous phyllite are respectively dark greenish gray and light greenish gray. The gray color of graphitic phyllite persists during weathering and chips of gray. phyllite can be found at the surface in soil developed on the Wildhorse Branch Formation. The tuffaceous units loose their greenish gray color during weathering and yield yellow, brown, and brick-red soils.

The presence of graphitic phyllite is probably the most reliable key to identifying the Wildhorse Branch Formation in the field. The total amount of greenstone and felsic tuffaceous phyllite, as well as the relative proportions of each, are quite variable. Graphitic phyllite is also known to occur in the Richtex Formation, however the presence of other characteristic lithologic types in the Richtex Formation precludes confusing it with the Wildhorse Branch Formation.

Some meager evidence suggests that the stratigraphic contact between the Wildhorse Branch Formation and the overlying Persimmon Fork Formation is unconformable. The contact in question is relatively abrupt, and the complexity of minor structures in the Wildhorse Branch Formation, such as multiple directions of foliation and crinkling suggest at least two deformational episodes, whereas the simplicity of minor structures in the younger Persimmon Fork Formation suggest simpler deformational history. However, confirmation of this unconformity hypothesis must await more detailed structural analysis of the rocks in question.

The Persimmon Fork Formation was originally deposited as a sequence of waterlaid dacitic tuffs interlayed with subordinate amounts of andesitic tuff and shale. These lithologic types have been converted to felsic tuffaceous phyllite, mafic tuffaceous phyllite and quartz mica phyllite respectively during regional low-grade metamorphism. Most outcrops of felsic tuffaceous phyllite contain bedded units, a few inches to several feet in thickness, which can be recognized because of minor variations in grain size and composition. Layers of quartz mica phyllite and mafic tuffaceous phyllite are more abundant in the lower part of the Formation, and in some places, mafic tuffaceous phyllite may predominate over other lithologic types. Most of the tuffaceous phyllite was deposited as sand or silt sized material containing larger lumps of pumice, which have been compacted to thin lenses of quartzofeldspathic material. Original plagioclase phenocrysts can be recognized in most thin sections. In some beds these phenocrysts are euhedral, but more commonly they show some rounding suggesting aqueous transportation and deposition, Rounded, pea-sized fragments of volcanic rock are ubiquitous, and in the lower part of the Persimmon Fork Formation some layers contain cobbles or bombs of volcanic rock more than one foot in diameter embedded in finer tuffaceous material.

A thick massive sequence of felsic tuffaceous phyllite, containing abundant angular fragments of highly strained blue quartz occurs within the Persimmon Fork Formation in the central part of the map area. This unit has been particularly useful in stratigraphic and structural work he-cause it is the only good “marker horizon” so far encountered in this part of the Slate Belt. It attains a maximum thickness of about 1,000' near the village of Ballentine and thins to the northeast and southwest.

The felsic tuffaceous phyllite in the Persimmon Fork Formation weathers to a light tan colored soil, whereas the mafic tuffaceous phyllite weathers to dark brown or brick red soil.

The best key to identifying the Persimmon Fork Formation in the field is its predominant felsic nature and the absence of argillite and graphitic phyllite which are characteristic of the Richtex and Wildhorse Branch Formations respectively.

The Persimmon Fork Formation grades gradually into the overlying Richtex Formation throughout about 500' of beds in which fine grained felsic tuffaceous phyllite is interlayered with argillite.

The Richtex Formation was originally deposited as a thick sequence of mudstone of probably turbiditic origin. This lithologic type has been converted into slate or fine grained phyllite by low grade regional metamorphism. The term “'argillite” has commonly been used to describe the slate and phyllite in the Richtex Formation, however this term is inappropriate because the rocks have a well developed slaty cleavage which is transverse to bedding in most places. This original bedding can be recognized in most outcrops of the Richtex Formation and consists of minute, graded laminae 0.1 to 5.0 mm thick. In some places these laminated slates are interbedded with layers of poorly sorted feldspathic sandstone 3" to 6' in thickness. The sandstone beds are also graded and contain chips and angular fragments of laminated shale incorporated from underlying material at the time of deposition. In a few places load casts and current grooves have been observed on the bottoms of sandstone beds.

In the central and northern part o£ the map area a thick sequence of andesitic or basaltic tuffs and amygdaloidal flows occurs in the lower part of the Richtex Formation. The se ma/lcVolcanic rocks resemble the mafic units in the Wildhorse Branch Formation, however, the association of mafic rocks with laminated slates occurs only in the Richtex Formation.

The Richtex Formation weathers to a yellow or brownish red soil, and fresh rock can be obtained only in strea sections. The *variability* of the color of soils derived fro the Richtex Formation suggests that there is considerable compositional variation in the laminated slates.

Considering the present stage of geologic mapping in SOuth Carolina, it would not be wise to attempt a precise correlation with the North Carolina Slate Belt stratigraphy of Conley and Bain {1965). However, the gradational change from the coarse grained tuffaceous phyllites of the Persimmon Fork Formation into the laminated slates of the Richtex Formation probably correlates with the base of the Tillery Formation in North Carolina. St. Jean (1964) has described a Cambrian trilobite from a stratigraphic horizon above the Tillery in North Carolina. For this reason the stratigraphic units in the Slate Belt of South Carolina are believed to be of Cambrian or Late Precambrian age.

CHARLOTTE BELT STRATIGRAPHY

The boundary between the tow grade metamorphic rocks of the Slate Belt and the medium to high grade metamorphic rocks of the Charlotte Belt trends about BT 80° E through the north-central part of the map area, and roughly separates the area mapped by Wagener on the north, from the area mapped by Secor on the south. Throughout most of its length, this metamorphic transition occurs in the Richtex Formation, which is the youngest stratigraphic unit in the State Belt sequence in South Carolina. The hypothesis that the medium to high grade of metamorphism of the Charlotte Belt is related to the outcrop of older, more deeply buried rocks is therefore untenable. Both Secor and Wagener agree that some of the stratigraphic units in the Charlotte Belt are the same as the stratigraphic units in the Slate Belt. Wagener believes that some of the rocks in the Charlotte Belt east of the coarse grained adamellite pluton are younger than any of the stratigraphic units observed in the Slate Belt, whereas Secor believes that the rocks in question correlate with Persimmon Fork-Wildhorse Branch Formations (see geologic map). This question is a difficult one to resolve because of poor exposures and extensive metasomatism and recrystallization in the Charlotte Belt.

METAMORPHISM

The grade of metamorphism varies systematically from the green-schist facies in the Slate Belt to the amphibolite facies in both the Charlotte Belt and the Spillway structure. The local Occurrence of pyroxene in the northern part of the area in the Charlotte Belt may indicate incipient development of the granulite facies.

Most of the State Belt terrane in the map area contains mineral assemblages characteristic of the quartz-albite-epidote-biotite subfacies of the greenschist facies. Almost all of the rocks studied in thin section contain quartz, muscovite, albite, epidote, and chlorite in different proportions. Felsic tuffaceous phyllite and mica phyllite normally contain only small amounts of epidote and chlorite, whereas these minerals may predominate in the metamorphosed andesitic and basaltic tuff. Although biotite occurs in only about 20 percent of the sections examined, its areal distribution is so general that most of the Slate Belt must belong to the biotite subfacies. Other minerals occasionally found are chloritoid, zoisite, graphite, paragonite, actinolite, calcite, and opaque ore. Paragonite occurs only in the absence of albite. The occurrence of zoisite and epidote together in the same rock as well as the common alteration of biotite to chlorite suggest chemical disequilibrium

In spite of the above metamorphism, many primary sedimentary or volcanic features can still be recognized. The coarse grained tuffaceous phyllite in the tower part of the stratigraphic sequence contains lens of qyartzofeldspathic material interpreted as compacted pumice lumps, and euhedral, twinned phenocrysts of volcanic plagioclase, now sieved with epidote, can also be recognized. Rounded detrital fragments of quartz and volcanic rocks are ubiquitous. In some places rounded or irregular amygdules can still be recognized in what must have originally been submarine lava flows. These amygdules are now filled with coarse grained quartz, albite, calcite, epidote, and actinolite. Gross compositional layering reflecting original bedding can be observed in most large outcrops, and the thin graded beds in the laminated mudstones o£ the Richtex Formation are still well preserved in spite of metamorphism and the development of cleavage transverse to bedding.

There is a marked increase in the degree o£ recrystallization along the border between the Slate and Charlotte Belts, so that it becomes more difficult to recognize primary sedimentary or volcanic features. In this region the albite, chlorite, epidote, and actinolite, so characteristic of the Slate Belt, disappear and are replaced by calcic plagioclase, pleochroic amphibole and rarely, garnet. The quartz-albite-epidote-almandine subfacies may occur in this transition zone, but there has not yet been sufficient work done on plagioclase compositions to confirm this hypothesis.

Most of the rocks in the Charlotte Belt have been metamorphosed in the amphibolite facies. Mineral assemblages such as quartz-micro-cline-plagioclase-muscovite-biotite-garnet are found in felsic gneisses, whereas the amphibolites contain hornblende and plagioclase with accessory carbonate, biotite, sphene, and rarely quartz, The local development of pyroxene in some amphibolites suggests incipient granulite metamorphism. Sillimanite is found in the rocks around the large adamellite plutonic complex in the north-central part of the area.

Epidote hornfels and hornblende hornfels occur locally around some of the small adamellite plutons in the Slate Belt. However these contact aureoles are only a few tens of feet thick and have not been studied in detail. An outcrop band of spotted slates in the Richtex Formation borders the south side of the large adamellite plutonic complex near the Slate Belt-Charlotte Belt border.- This may be a broad zone of contact metamorphism, but it may also simply be part o£ the regional transition into the higher grade rocks of the Charlotte Belt. Within the Charlotte Belt it has not been possible to differentiate the effects of contact metamorphis from regional metamorphism. Both the plutonic rocks and the metamorphic rocks appear to have been generated in a single thermal episode.

STRUCTURE

A series of major fold axes trending N 80° E have been recognized in the Slate Belt rocks exposed in the map area. These folds have amplitudes and wave lengths of thousands of feet. Axial planes are inclined 75°-85° to the northwest, and most of the folds are overturned toward the southeast. This direction of overturning is opposite to that normally found in the southern Appalachians. The Slate Belt may therefore be one of the few places where the southeastern flank of the Appalachian Geosyncline can be studied.

A secondary metamorphic foliation which parallels original bedding is well developed in the rocks of the Persimmon Fork and Wildhorse Branch Formations. This foliation wraps over the crests of folds and may be used in the same way as bedding to interpret geologic structure. Minor folds and crinkles (b-lineations) occur in most outcrops, and in a statistical sense the plunge of these linear structures parallels the plunge of the associated major folds.

Slaty cleavage, transverse to bedding, pervades most of the rocks of the Richtex Formation. This cleavage approximately parallels the axial planes of major folds, and the line of intersection between cleavage and bedding parallels the fold plunge (Brown, ms). This slaty cleavage is believed to have resulted from tectonic compaction and dewatering of the pelf-tic sediments in the Richtex Formation during the early stages of deformation.

Structural complexities such as multiple crinkle directions, kink bands, and crinkling of slaty cleavage can he observed in some Slate Belt outcrops. The significance of these are not presently understood. A detailed study of structural paragenesis in the Slate Belt would probably yield much useful information on the geologic history of the Piedmont.

Several large faults trending N 75 ° E to E-W cross the map area. These faults cut across fold trends at a small angle and appear to be vertical or very steeply dipping. The stratigraphic units of the Slate Belt have been randomly juxtaposed across these faults. In a few places vertical crinkle lineations have been observed in or near the fault zones. This fact along with the gross map pattern suggests that the faults have a large component of strike-slip displacement. One of the main objectives of detailed mapping in the Slate Belt has been to find net slip criteria for these faults. but this effort has so far been unsuccessful. In some places dike-like bodies of silicified breccia have been found associated with the' faults. However these breccia bodies do not normally coincide with the main fault trace as determined from stratigraphic evidence. The faults have been intruded by late Paleozoic granitic plutons and are cut by northwest trending Mesozoic diabase dikes.

Folds and faults are more difficult to recognize in the Charlotte Belt rocks because the original nature of the rocks is masked by extensive recrystallization and plutonic activity. In general foliation trends wrap around the large pluton of adamellite in the Charlotte Belt suggesting that it was emplaced at least in part by forceful injection. However there is also convincing evidence that some of the Charlotte Belt rocks were partially melted in place.

THE SPILLWAY STRUCTURE

An anomalous area of medium grade metamorphic rocks, occurs in the Lake Murray Spillway in the southern part of the map area. This Spillway Structure is actually the northeast end of a belt of igneous and high grade metamorphic rocks that extends southwestward into Georgia (Overstreet and Bell, 1965). A series of gneisses and schists occur in the Spillway, and these have quartz-microcline-plagioclase-muscovite-biotite, and quartz-plagioclase-muscovite-biotite-chlorite-garnet-staurolite-kyanite-amphibole mineral assemblages respectively. Aureoles of progressively lower metamorphic intensity occur around the Spillway and separate it from the low grade Slate Belt rocks. The geology of the Spillway has been investigated by Heron (1950), Heron and Johnson (1958), Kiff (1963), and Tewhey (ms). Tewhey (ms) concluded that the gneiss in the Spillway is a metasedimentary rock diapirically intruded into the overturned limb of an anticline. The intense crumpling of the associated schists about vertical fold axes supports this interpretation. Stratigraphic units and metamorphic aureoles are greatly sheared out and thinned along the southern edge of the Spillway structure. In this area it is possible to pass from the thoroughly recrystallized metamorphic rocks of the Spillway into the low grade metamorphic rocks of the Slate Belt by going about 1,000' in a southerly direction. A major fault marked by silicified breccia parallels this shear zone in the low grade rocks south of the Spillway structure.

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SATURDAY ROAD LOG

Mileage	*Explanation*
0.0	Leave parking lot at Howard Johnson's Motel (400 Knox Abbott Drive and proceed west on State Street.
0.5	Junction U.S. #1, turn right, cross bridge over Congaree River. Note exposures of granitic rock in river bed.
1.3	Junction Huger Street (traffic light). Turn left.
2. 1	Bear right on Elmwood Avenue, Work into center or left lane.
2.8	Turn left on Main St. (U. S. 321). Follow signs for S.C. 215.
4.8	Bear left on S.C. 215.
5.7	Basal gravels of Coastal Plain sequence on left.
6.1	Highly weathered phyllite outcrop of Richtex Formation on right.
6.3	Cross 1-20.
10.5	Westernmost edge of Coastal Plain exposures on right,
11.2	Small exposure of Richtex Formation on right.
13.3	Cross major fault separating Richtex Formation on the south from the Wildhorse Branch Formation on the north.
13.5	Cross small apophysis of Harbison adamellite pluton. Note sandy brownish yellow saprolite.
14.0	Exposure of tuffaceous phyllite in Wildhorse Branch Formation.
15.6	**STOP #1.** Bridge over Cedar Creek. Fresh exposure of fine grained felsic tuffaceous phyllite of the Persimmon Fork Formation. Bedding is N 83° E 48° NW, small folds and crinkles plunge 10 ° N 71° E. Minor structures indicate that outcrop is on the southeast flank of a syncline (or on the northwest flank of an anticline). This rock contains quartz, albite, epidote, chlorite, actinolite, muscovite, biotite and ore in varying proportions. A weathered exposure of the felsic tuffaceous phyllite with blue quartz fragments occurs along the road a few hundred feet northwest of the-bridge.
15.8	Note weathered diabase boulders in ditch. These originate from a diabase dike about 40' thick, which strikes N 30° W parallel to Rt. 215 for several miles.
18.0	“Shale” quarry in Richtex Formation. Material used for brick manufacture.
19.5	Cross Little River Bridge. Turn left on Richtex road.
20.5	**STOP #2.** Richtex Brick Plant and “shale” quarry. Weathered slate of the Richtex Formation. Laminated bedding can be seen in some places. Felsic dike strikes along the north wall of the quarry. Turn around and return to S. C. 215.
22.3	Turn right on S. C. 215.
22.5	Turn left on county road S-40-944.
23.2	**STOP #3.** Weathered outcrop of the Richtex Formation, illustration of cleavage, Bedding and minor folding.
25.4	Cross southern border of coarse grained adamellite pluton.
25.5	Note adamellite saprolite and sandy soil.
25.6	Turn right on county road S-Z0-420.
26.0	Turn right on S. C. 269.
28.2	Turn left on county road S-40-1435.
29.3	Diabase dike trending N 35° W. This is one of several dikes in this vicinity. Most of these are normally magnetized, one is reversed.
29.8	Turn left on county road.
30.2	Cross gradational contact between Richtex Formation and Persimmon Fork Formation.
30.5	Outcrop of felsic tuffaceous phyllite in the Persimmon Fork Formation.
30. 7	**STOP #4.** White micaceous phyllite in the Persimmon Fork Formation. Bedding and foliation are parallel. A fresh sample collected in the creek to the south contained quartz, muscovite and paragonite. A diabase dike striking north - south crosses the western end of this road cut.
31.6	Turn right on county road S-40-967.
31.8	Felsic tuffaceous phyllite intruded by metamorphosed mafic sills.
32.0	**STOP #5.** Felsic to intermediate tuffaceous phyllite containing about 5 percent rounded fragments of volcanic rock up to 6" in diameter. Are these volcanic bombs or waterworn cobbles? Bedding is N 53° E 63° NW. This unit is near the bottom of the Persimmon Fork Formation.
32.4	Turn left on county road.
33.8	Turn left on county road S-40-1209.
33.9	Bear right across U. S. 321 onto county road S-40-406.
34.0	Exposure of felsic tuffaceous phyllite i.n Wildhorse Branch Formation.
34.8	Turn left on county road S-40-1335.
35.4	**STOP #6.** A series of amygdaloidal flows, each several feet in thickness are interbedded with thinner tuffaceous layers. Layers of graphitic phyllite and felsic

tuffaceous phyllite also occur. Bedding is N 70 ° E 85° NW. The pelitic units contain white mica, biotite, graphite and a trace of quartz, whereas the flow units contain quartz, feldspar, biotite, epidote and ore. Wildhorse Branch Formation.

35.5 Note thick maroon saprolite developed on mafic units of the Wildhorse Branch Formation.

35.7 Turn left on county road S-40-59.

37.4 Turn right on U.S. 321

37.8 **STOP #7.** A well exposed sequence of bedded felsic tuffaceous phyllite of the Persimmon Fork Formation. Bedding is N 65° E 80° NW. A few thin metamorphosed mafic sills are also present.These locally cut across bedding in the tuff sequence.

39.4 Turn right on county road S-20-93.

39.5 **STOP #8.** Park on right side of state road 93 (dirt road). Hike east on logging road about 0.9 mile and observe saprolitic outcrops.

Cobbles at starting point of hike are amphibolite typical of the mafic volcanic group near the greenschist facies-almandine amphibolite facies isograd. White splotches are deformed amydules

Mineralogy: green amphibole (hornblende), plagioclase, tremolite, epidote, sphene, quartz, chlorite (rare).

Contact with Cambrian argillite group will be crossed about 0.3 mile after start of hike. Units observable: laminated and nonlaminated rneta-argillite (white mica phyllite); interlayered with rnetasiltstones (dense rocks resernbling andesite); highly siliceous metasiltstones (up to about 60 percent quartz) that appear cherty; very thin felsic tuffs(?). Mineralogy of metasiltstones: quartz, plagioclase, epidote, white mica, biotite(?), colorless garnet (rare), green amphibole (rare).

40.8 Proceed north on road 93 to state road 30. Note alternating thick salic and mafic units of mafic volcanic group exposed as fresh rock on road surface and in ditches. The salic units are generally quartzo-feldspathic and thought to be meta-arenites or rnetasiltstones; color index is generally very low.

41.7 Proceed east on state road 30 to state road 115. Road follows strike of a hornblende-tremolite amphibolite that has a greenish weathering cast. Soil is greenish brown, typical of soils on hornblende-rich rocks of all metamorphic grades.

43.7 Proceed north on state road 115 to highway 34. Contact with schistose facies of meta-arenite group is crossed about 0.5 mile north of road 30. This facies o£ the meta-arenite group is composed of very poorly exposed muscovite schists and quartzites, probably interlayered with quartzo-feldspathic rneta-arenites(?).

44.3 Proceed east on highway 34 to first dirt road. Turn left **with caution —** heavy truck traffic.

50.0 Follow this dirt road for nearly six miles to its end at a stop sign at a “T” intersection opposite a gravel pit. For the first three miles, this road is in the quartzo feldspathic facies of the meta-arenite group. The poorly exposed rocks are granitic granofels and biotite and hornblende gneisses with some quartzite on the south, and some interlayered amphibolite on the north. The large valley extending eastward to the horizon is the topographic expression of a pyroxene gabbro. The last two miles On this road are in mafic (red soil) and salic units of the mafic volcanic group. The very low color index of the gneissic and granofelsic units is reflected by white saprolite and soil.

50.4 Turn right at “T” intersection and proceed to Stop 9.

STOP #9. The mafic volcanic group here is in the upper almandine amphibolite facies of regional metamorphism. Some amphibolites bear orthopyroxene and clinopyroxene; others are free of pyroxene. Interlayered granitic granofels is still fine-grained, and no garnet has been observed. Other units to the north and south, however, do bear garnet. Mineralogy of granofels: quartz (30-40%), plagioclase, biotite, accessories (includes K-feldspar).

This stop is in a belt of maximum regional metamorphic grade that extends across the northern portion o£ the map area from southwest to northeast. Northwest of this stop (at Stop 10 and elsewhere), rocks are either at similar grade or somewhat retrogressed, but recrystallization has produced coarser textures, and premetamorphic textures have been completely destroyed.

Retrogression in most amphibolite specimens examined appears to be restricted and local. Conversion of hornblende to tremolite is generally associated with introduction of quartz and K-feldspar along veinlets. Some specimens exhibit no evidence of retrogression.

54.3 Proceed north (turn around) on this dirt road to state road 41 (paved).

The last mile and one-half on this road is in high grade granitic gneisses of widely varying color index. Some of the units are rich enough in biotite to impart a deep red color to the soil, but a surficial sheen on the soil indicates that the iron oxide coloration is derived from decomposition of biotite, rather than hornblende, These rocks are thought to be equivalent to the Cambrian argillite unit on the south. The correlation is based on the apparent.existence of a large synclinorium, overturned to the south and plunging eastward. The limbs of this fold appear to be occupied by the mafic volcanic group.

Table 1. Modal and chemical data for gneiss and granodiorite in syntectic zone. Specimen 9004K is a thin "sill" between J and L. Analyses for Si, Ti, Mn, Rb, Sr, Zr by the University of North Carolina; others by The Citadel. (gn-gneiss; gr-granodiorite).

Modes (volume in percent				
	9004J (gn)	9004K (gr)	9004L (gn)	9303 (gr)
quartz	24. 3	28.9	37.3	25.0
plagioclase	43. 1	37.4	34, 1	37.3
microcline	17.6	28.6	21.5	23. 1
biotite	11.6	3.4	4. 9	8.6
white mica	0. 6	0. 1	0.8	1. 1
hornblende	0	0	0	2.4
opaques	1. 2	0.7	0.1	0.7
sphene	0.7	0.4	0.5	1.3
chlorite	Tr	0.3	Tr	0.1
epidote	0.2	0	0.4	0.1
other	0.6*	0.1	0.3*	0. 4
	99.9	99.9	99.9	100.1
* principally tremolite				

Oxides (weight percent)

	9004J (gn)	9004K (gr)	9004L (gn)	9303 (gr)
SiO_2	69.9	72. 6	73.4	67.8
TiO_2	0.4	0.3	0.4	0, 7
Al_2O_3	16.2	14.1	14. 8	15.0
Fe_2O_3	4.1	3.4	2.8	5.3
MnO	0.1	0. 1	0.1	0.1
MgO	1.1	0.5	0.5	1.1
CaO	2.4	1.5	1.8	2.3
Na_2O	4.7	2.5	3.1	2.6
K_2O	2.8	3.9	3.5	3.6
Total	101.6	98.9	100.4	98. 5
ppm Rb	100	103	88	116
ppm Sr	341	273	258	338
Ppm Zr	216	299	226	300

58.4 Proceed west on state road 41 past Wateree Creek to large gravel pit on north side of road.

Several deep cuts alone this road reveal the extent of recrystallization and mobilization (rheomorphism) of salic and some mafic units in this area.

STOP 10. Gravel pit. This exposure provides large quantities of relatively fresh material for observation, but the pit is being worked, and exposures are subject to change.

Amphibolites and medium-grained quartz-plagioclase-biotite gneisses are thinly interlayered in the northwest corner of the pit, The gneisses bear red garnet. Accessory tremolite is indicative of some retrogression in both gneiss and amphibolite. Accessory quartz, K-feldspar, biotite and sericite are associated with tremolite as replacement products of plagioclase and hornblende in amphibolite. Salic gneisses, such as the blocks piled in the center of the pit, and gneisses much richer in biotite throughout the northern portion of the map area contain thin pegmatoid lenses parallel to foliation. Some gneisses contain small areas where recrystallization (of fusion?} has destroyed foliation to produce granitoid texture.

The southwest corner of the pit contains one of the enigmatic granitoid bodies so common to this region. Whether it is a premetamorphic intrusion, a granofels produced from fetdspathic sediment, or a rheomorphic rock could not be determined. The body is cut by mafic dikes that have wide aureoles rich in pink alkali feldspar.

60. 1 Proceed west on road 41 to stop sign at state road 200. North of this intersection on road 200, salic and mafic gneisses are well exposed in deep cuts, mostly as saprolite.

63. 2 Proceed west on road 200 past stop sign at highway 321 to stop light on highway 321 By-Pass.

63.8 Proceed south on highway 321 By-Pass, turn right on paved road leading to Winnsboro Sewage Treatment Plant, and park. (This road is very easy to miss.) Walk across highway 321 and down the hill to creek bed exposures.

STOP 11. Syntectic zone and coarse-grained Winnsboro adamellite (here granodiorite) exposed in creek bed.

In this exposure, mobilization of salic gneisses at upper almandine amphibolite facies conditions has caused distortion and displacement of interlayered mafic units. The salic gneisses contain "sills" of coarse granodiorite that exhibit none of the effects attributed to chilling of a melt; that is, no phenocrysts or marginal decrease in grain size. Mineralogically and chemically, the gneisses and granodiorite are similar (Table 1). Some gneisses contain small zones with diffuse boundaries in which grain size has increased and approximates that of the granodiorite. It is proposed that fusion has occurred in the salic units, especially along contacts with units of differing mineralogy, and that whatever heat source produced high-grade metamorphism also caused fusion.

Reduction of heat flow in the waning metamorphic cycle permitted crystallization of melts. Water solutions absorbed by the melts were expelled, causing local retrogression of unfused high-grade salic and mafic units, generally along veinlets or compositional layering.

Upstream from this exposure quarried blocks of granodiorite exhibit evidence of reconstitution of amphibolite included in the melt, and excellent ghost stratigraphy is exposed in situ.

About halfway up the hill in a small tributary, more ghost stratigraphy is exposed, and large mafic slabs are included in granodiorite. On the hilltop above the creek bed exposures the northwestern nose of a large body of Winnsboro adamellite (here granodiorite) contains biotite schlieren and salic and mafic inclusions. Both schlieren and inclusions have the same structural orientation as compositional layering in the creek bed exposures below.

64.6 Proceed south on highway 321 By-Pass to state road 61.

69.3 Proceed west on road 61 to stop sign at intersection with state road 213.

73. 2 Continue west on 213 to dirt road leading north to Stop 12.

Roads 61 and 213 pass over high-grade gneisses, mafic rocks and muscovite-sillimanite schists and gneisses, and a large body of Winnsboro adamellite. Much of the metamorphic material has been involved to varying degrees in rheomorphism and anatexis.

73.5 Turn right on this dirt road and park along right fork at forked intersection (right fork leads to lake).

73. 9 Walk along left fork of road to exposure of sillimanite quartzite.

Please avoid unduly upsetting the numerous cows and horned bulls peering from the underbrush.

STOP 12. Sillimanite quartzite. Muscovite-bearing metamorphic rocks in the western map area have been converted to muscovite-sillimanite schists. Neither andalusite nor kyanite were observed, but cordierite does occur. Most of these rocks are quartzose or quartzofeldspathic. The feldspar, if any, is plagioclase; K-feldspar does not occur in the muscovite-sillimanite schists examined. This large exposure is of unusually large grain size, and relatively little muscovite remains. The mode obtained for one specimen was about 55 percent quartz and 45 percent sillimanite. Unfortunately, because of finely intergrown sillimanite needles and quartz, it does not appear feasible to obtain a commercial separate fro this rock.

74.2 Proceed west on road 213 to road 114, leading to Winnsboro “blue granite” quarry.

74.8 Proceed south on 114 (down steep grade) and park beside stone buildings by railroad

STOP 13. Winnsboro “blue granite” quarry. The Winnsboro Blue Granite is a fine-grained phase of the Rion adamellite, which is intrusive into high-grade metamorphic rocks and the coarse-grained Winnsboro adamellite. The large Rion adamellite pinion east of here is porphyritic in marginal areas, but medium-grained and equigranular in appearance in central zones, as at the large crushed stone quarry at Rion. This large pluton appears to have made room for itself by shouldering aside enormous volumes of metamorphic rock. There is a pronounced bending of regional structures around this body on the south.

The “blue granite” quarry has been in operation for about 75 years. The original pit was opened directly above the intersection of two basaltic dikes, and was abandoned after the dike intersection was quarried through. The result: a text-book exposure of the dikes in three dimensions. One of the dikes intersects the rock face west of this pit. Intrusion of the dikes caused fusion of adamellite, and the fusion product reacted with basalt to produce an intermediate rock. Pegmatite dikes derived from the fusion zone injected the adamellite along joints.

The pit now being worked is west of the original pit. Sometime after the new pit was opened the old method of multiple drilling to split off blocks was abandoned in favor of utilization of a jet of very hot air. This change is reflected in the quarry face.

Field trip ends here. Return to Columbia is easiest by following road 213 about 3 miles west to stop sign at intersection with highway 215, and taking 215 south to Columbia. Alternately, take 213 east about 9 miles to stop sign at highway 321, and take 321 south to Columbia.

SUNDAY ROAD LOG

Mileage *Explanation*

0.0 Drive west on State Street.

0.5 Turn left on U. S. 1.

0.6 Turn right on Leaphart Road.
0.8Bear left on Sunset Boulevard.
4.0Turn right on 1-26.
4.7Bear left through interchange, stay on 1-26 west.
12.8Bear right at Ballentine exit. Follow U. S. 76 west.

15.8Bear right on U. S. 176.
15.9Turn right on county road S-40-80.
18.5STOP 14. --Silicified breccia in fault zone between Richtex and
Wildhorse Branch Formation.

Turn around and go back south on S-40-80.

20.7 Turn right on U. S. 176.

21.4 **STOP 15.** Fresh exposure of felsic tuffaceous phyllite with Blue quartz fragments.

21.8 Turn right on county road S-40-286.

23.1 Turn left **on U.** S. 76.

23.2 Turn right on S.C. 6 to Lexington.

24.0 Outcrop of upper Persimmon Fork Formation. Minor folds plunge 15° NE.

28.9 Lake Murray Dam and power plant.

29. 7 **STOP 16.** Lake Murray Spillway. See text for description of Spillway geology.

Return to Columbia.

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