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RELATIONSHIPS BETWEEN THE CAROLINA SLATE BELT AND THE CHARLOTTE BELT IN NEWBERRY COUNTY, SOUTH CAROLINA

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INTRODUCTION

Location

Newberry County is in the northwestern part of South Carolina, with Newberry, the County Seat, lying approximately forty miles northwest of Columbia, the state capital. The Broad and Enoree Rivers bound the county on the east, and the Saluda River and Lakes Greenwood and Murray mark the southern boundary. The total area of the county is about 628 square miles.

Previous Geological Work

No extended systematic research has previously been done in this area. Kesler (1936) discussed granitic injection processes in the Columbia Quadrangle, which includes much of eastern Newberry County. Buie and Robinson (1949) showed the extent of the Slate Belt rocks in Newberry County in their study of the distribution and properties of the “shales” of South Carolina.

Present Geological Work

The present study is one of a number of country mapping projects recently initiated in South Carolina by the Division of Geology, S.C. State Development Board. The field work was begun in the summer of 1959 and has continued intermittently to the summer of 1961. The field and laboratory work are now essentially complete and report writing is in progress. In addition to the writer’s work, two other projects that include portions of Newberry County are now in progress. John C. McKenzie, graduate student, University of south Carolina, is engaged in detailed mapping of the kyanite occurrences at Little Mountain; and Kenneth Drummond, now of the North Carolina Division of Mineral Resources, is doing a zircon study of the various granitic intrusives of both the Slate and Charlotte Belts in Newberry, Fairfield, and Lexington Counties.

Purpose

Since Newberry County lies across both the Charlotte and Carolina Slate Belts it has provided a reasonably good map unit for studying the gross relationships of these belts. The purpose of this trip will be essentially to demonstrate these relations in so far as time and distances permit.

GENERAL GEOLOGY

Physiography

The county lies entirely within the Piedmont Physiographic Province, which is essentially a dissected peneplane. The divides are relatively broad and the relief is low. This relief averages about 100 to 200 feet over most of the county but reaches a maximum of 300 feet at Little Mountain, a monadnock rising to an elevation of almost 800 feet. Little Mountain lies within a belt of hills generally greater than 600 feet in elevation which mark the northwestern edge of the Slate Belt. Comparable elevations are not encountered in this portion of the Piedmont until the town of Clinton in Laurens County is reached, a distance of approximately thirty miles to the northwest.

The drainage pattern in the south central Piedmont has generally been described as dendritic. However, in Newberry County a pronounced angularity to the stream pattern exists. This is best seen in the area between Newberry and Whitemire and along the shore line of Lake Murray. The two most pronounced stream directions are N. 20° W. and N. 50° E. The regional slope is S. 30° E. and the regional strike is N. 70° E. These directional elements have undoubtedly influenced the pattern but additional factors seem to be involved. A study of the joints at approximately thirty stations over the county indicates that the two most pronounced fracture directions correspond even more closely to the stream pattern that do the strike and regional slope. This suggests that the fracture system may have played an important role in the development of the angular drainage pattern.

Chemical weathering has produced deep lateritic soils and saprolites over almost the entire county. Natural outcrops are rare but the secondary streams and deeper roadcuts, along with scattered quarries, provide fresh samples of all the major rock units. Certain soils were found to be useful in tracing some of the rock units. A recent U.S. Bureau of Agriculture Soil Survey of the county proved to be very helpful in some aspects of the field mapping (Camp, 1961).

Stratigraphy and Structure

Carolina Volcanic-Sedimentary Group

Carolina Slate type rocks are exposed over the southeastern portion of Newberry County. The term Carolina Slate is now generally understood to be inappropriate, and various substitute names have been proposed. Perhaps the most generally applicable of these is Carolina Volcanic-Sedimentary Group, proposed by Stromquist and Conley (1959). This term will be used formally and the shorter name "Slate Belt" will be employed informally.

The group consists of low rank phyllites and semischists derived predominantly from volcanic flows and tuffaceous sediments. The overall chemical character varies from mafic to felsic with an average composition that is andesitic (McMauley, 1961). The oldest "Slate Belt" rocks in Newberry County consist of felsic volcanic flows and tuffs interbedded with minor mafic tuffs and tuffaceous sediments. They are exposed along the southeast flank of an anticlinorium within which older higher rank metamorphic and plutonic rocks of the Charlotte Belt are exposed. The lowermost, predominantly felsic portion of the "Slate Belt" is overlain by a thick accumulation of intermediate volcanics and tuffs, mafic tuffs (in greater abundance) and hematitic schists or phyllites. Kyanite and muscovite quartzites along with some felsic volcanics are present locally in the upper part of this section. Poor exposures, structural complexity and the limitations of the present project have prevented this subdivision from being applied in terms of mappable units. Further detailed work, particularly to the southeast in Richland and Lexington Counties, may yield a more complete picture of the stratigraphy within the "Slate Belt".

In addition to the stratigraphic differences, a change in the degree of metamorphism is encountered as the western margin of the "Slate Belt" is approached. The rocks to the west have undergone a higher degree of shearing and recrystallization and are now mostly medium to fairly coarse grained schists.

Mineralogically the rocks of the Carolina Volcanic-Sedimentary Group consist predominantly of quartz, plagioclase, sericite, chlorite, epidote and the opaque minerals pyrite, hematite, and ilmenite. Modal analyses of selected samples are given with the description of various field stops. All the units of the group in Newberry County are within the greenschist metamorphic facies. This uniformly low regional metamorphic rank is one of the most important features of the belt, and is one of the chief criteria used in distinguishing these rocks from those of the Charlotte Belt. Higher rank metamorphic rocks are present within the "Slate Belt" but can be attributed to local upgrading marginal to discordant granitic plutons. No large granitic intrusives are present within the "Slate Belt" of Newberry County.

The folding in the Volcanic-Sedimentary Group is fairly tight with a general northwestward asymmetry. The smaller folds are inferred to be drags on the limbs of a major east-northeast trending synclinorium whose axis lies to the south of the county line. Several of these fold axes are seen in Figure 1. Figure 2 is a cross section of both the "Slate" and Charlotte Belts and shows the northwestern limb of this synclinorium, which is marked by a chain of hills in the southern part of the county. The monadnock at Little Mountain is a part of this chain. Lineations indicate that the plunge of this major structure is to the east-northeast at about ten degrees.

Bedding in the rocks can best be seen by means of compositional banding. In many places the foliation is parallel to this layering. However, at some localities a reasonably well developed axial plane cleavage can be seen. This cleavage, where developed, is steep dipping which indicates that although the folds are relatively tight the beds are generally in an upright position. Locally there is, however, some overturning of the forelimbs. The intersection of this axial plane cleavage and the bedding gives rise to a good lineation which generally plunges northeastward. At those localities where axial plane cleavage is developed the rock breaks into rod or pencil-like fragments bounded by the two foliation planes.

Charlotte Belt

The term Charlotte Belt was, to the writer's knowledge, first used by King (1955) and was applied to the predominantly plutonic terrane which borders the "Slate Belt" in both South and North Carolina. The rocks consist of massive to weakly foliated granite to granodiorite intrusive into what the writer informally calls Charlotte Belt Gneiss. This gneiss unit consists of amphibolites or hornblende gneisses, quartz-biotite and quartz-microcline gneisses and various types of migmatite marginal to the major plutons. The original pre-metamorphic character of this terrane is inferred to by predominantly mafic (McCauley, 1961). However, the mafic character of these rocks has been largely obscured by the addition of considerable quartzofeldspathic material in the form of sills and dikes along with the partial or complete assimilation of large areas of the original country rock, all the result of late orogenic magmatic activity.

Figure 1 shows the general distribution of these Charlotte Belt rock units. A large granitic pluton is centered to the north of the town of Newberry. This pluton is partially concordant with the regional structure, but in its northern and western portions it is clearly discordant and distorts the foliation of the country rock around to a northerly or northwesterly direction. Foliation resulting from flowage within the pluton itself is also oriented in a northerly direction in this area (McCauley, 1961, Plate 1). The smaller intrusives in the eastern part of the county are generally concordant whereas those in the western part diverge from the regional strike.

Considerable evidence for the intrusive character of these plutons exists. Their previously mentioned partially discordant character is the first point. The second is that the foliation of the country rock at the margins of the plutons is generally steep dipping to overturned. The third point is the presence of disoriented mafic zenoliths throughout the granitic masses but particularly abundant near the contacts. A fourth point in favor of the intrusive character is the presence of dome-like structures in the Charlotte Belt Gneiss. The best developed of these is about three miles southeast of the

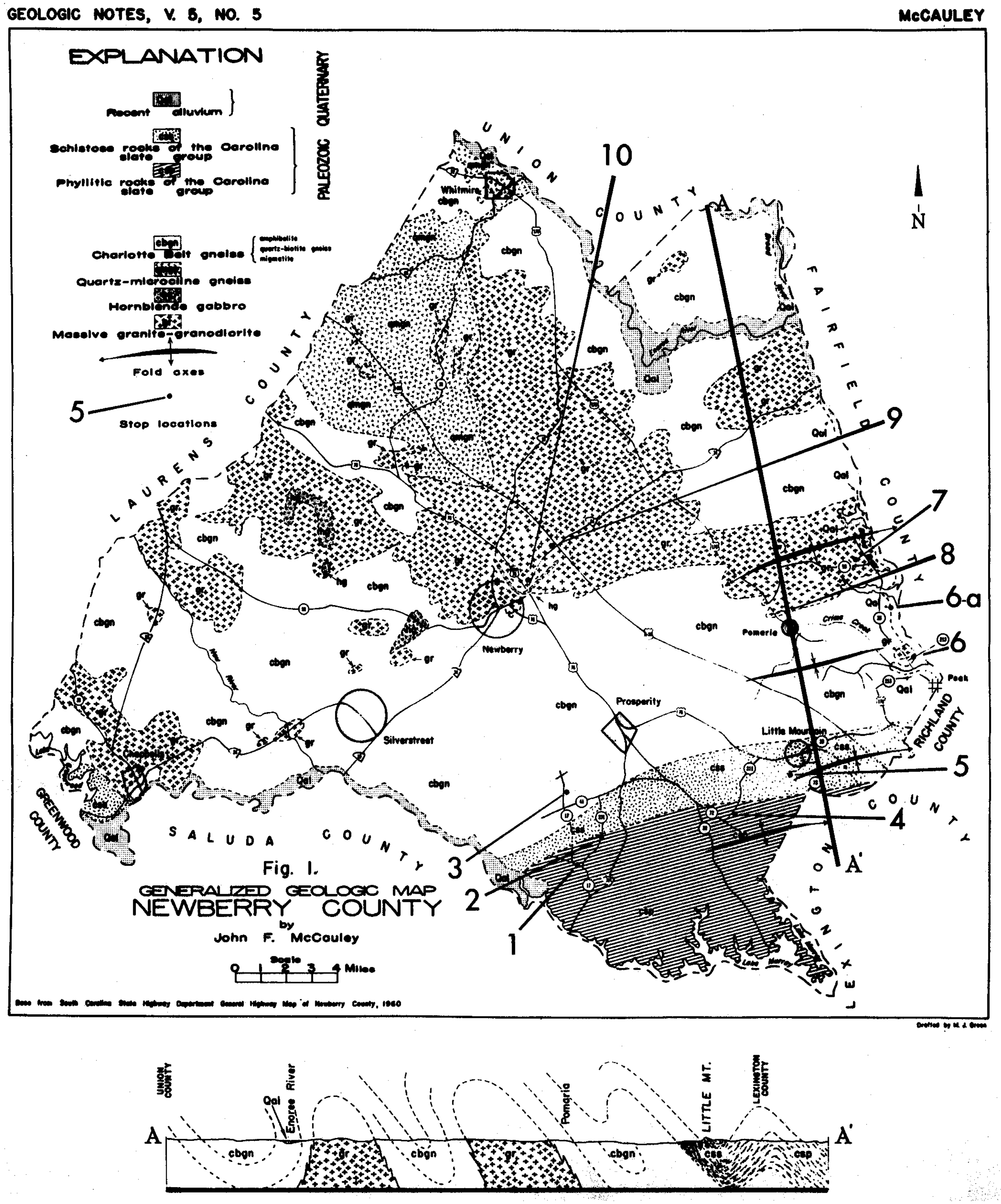

Figure 1. Geological Cross Section.

town of Newberry. These domal structures are attributed to subjacent intrusive masses which have not yet been exposed by erosion.

The intrusive character of these plutons does not preclude an origin by some process of deep seated granitization. However, the present erosion surface is closer to the source of the plutons in the Charlotte Belt than it is in the "Slate Belt", where the granites were emplaced into younger rocks at considerably higher crustal levels. It is considered probable that the granites of both belts are essentially contemporaneous and that they may have originated from the same magma chambers. Zircon studies now in progress should provide additional data to test this hypothesis.

The Charlotte Belt rocks, both the granites and earlier formed gneisses, are intruded by very late orogenic gabbros (McCauley, 1960). These are in the form of irregular plugs and crescent shaped dikes. These bodies are all retrogressively altered and the present mineral assemblage consists essentially of fibrous amphiboles, biotite and plagioclase. Pegmatites crosscut these gabbros and are inferred to be the principal retrogressive agent. These pegmatites attest to a very young cycle of granitic intrusion which postdated the formation of the major granitic plutons.

Also present within the Charlotte Belt are smaller mafic dikes now extensively chloritized. These are similar in general appearance to some of the mafic units in the "Slate Belt" rocks. The best exposures of these dikes can be seen in the roadcut at Pinners Bridge (Stop 6). These dikes postdate the regional metamorphism of the hornblende gneiss and the crystallization of the main granite plutons but are cut by the late cycle granitic pegmatites. The amphibole gabbros exhibit the same chronological position and may actually be genetically related. However, positive evidence for this view is lacking.

In addition to the folding and magmatic activity in both belts a pronounced N. 20° W. fracture direction is prominent. This direction, as previously mentioned, corresponds with one of the elements of the angular drainage pattern. In addition, the great majority of the Triassic (?) diabase dikes in the central Piedmont trend from N. 10° W. to N. 30° W. At Little Mountain there is evidence of faulting in the same general direction. Cannon Hill, also a kyanite quartzite monadnock, is offset to the north and west a distance of about three quarters of a mile from the strike of the kyanite ridge that forms the backbone of Little Mountain. The trace of this fault is marked by a stream valley along which scattered pieces of what appear to be fault gouge have been found. Two pronounced notches or gaps in Little Mountain itself mark the trace of smaller northwest trending faults which offset the kyanite quartzite beds. Similar displacements undoubtedly exist in the surrounding "Slate" units but they cannot be recognized because of poor exposures and the lack of marker beds.

In the Charlotte Belt the fold pattern developed during initial orogenesis has been modified by later granitic intrusions which have domed the foliation at certain places and cut across the regional strike in others. The northwestward prong or extension of the pluton centered to the north of Newberry is a good example of this distortion of the regional fold pattern. It is interesting to observe that the strike of this prong is N. 20° W. the same distance as the previously discussed pronounced fracture pattern. It is probable that the granite utilized this direction of weakness during the magmatic cycle to provide itself with sufficient lateral space. This probability along with the northwest trending faults at Little Mountain suggests that the fracture pattern developed considerably prior to Triassic time.

GENERAL RELATIONSHIPS BETWEEN THE BELTS

The general relationship between the "Slate" and Charlotte Belts in Newberry County is that of a synclinorium to an anticlinorium. The low rank metavolcanics and metasediments of the "Slate Belt" are part of a broad synclinal flexure whose axis lies to the south of the Newberry County line. The rocks exposed within the country are on the northwestern limb of this structure. The lowermost "Slate" unit is relatively resistant and is expressed topographically by a chain of low hills trending parallel to the regional strike.

The Charlotte Belt rocks are part of the adjacent anticlinorial structure flanked on the east by younger "Slate Belt" rocks and on the northwest by the schists of the Kings Mountain Belt in Laurens County, recently described by Overstreet (1960). The younger "Slate" rocks on the east flank of this structure are inferred to represent relatively shallow water accumulations of mafic to felsic tuffs and volcanics with an average composition that is andesitic. The original rocks of the Charlotte Belt, now represented by hornblende and quartz-biotite gneisses, were deeper water earlier accumulations of submarine volcanics and graywackes. Thus the two groups of rocks simply represent different geosynclinal environments. The cause of the anticlinorial folding in the Charlotte Belt can be related in part to the emplacement of large masses of granite which must have domed the overlying strata to great height.

Some high angle faulting is probable present along the margin of the two belts which may cut out part of the lower "Slate" section in this area (McCauley, 1959). Faulting along the western margin of the Volcanic-Sedimentary Group in North Carolina seems to be fairly well established (Laney, 1910; Guidrox and Mann, 1961). However, this faulting appears to be a subordinant structural feature to what the writer considers the major tectonic elements of the area, i.e., a "Slate Belt" synclinorium marginal to a broad anticlinorium in the Charlotte Belt.

REFERENCES CITED

Buie, B.F., and Robinson, Gilbert C., 1949, The distribution and properties of the shales of South Carolina: S.C. Research Planning and Development Board, Bull. 19, 58 p.

Camp, Wallace, J., 1960, Soil survey of Newberry County, South Carolina: U.S. Dept. Agri., Series 1956, No. 10, 62 p.

Espenshade, Gilbert H., and Potter, Donald B., 1960, Kyanite, sillimanite, and andalusite deposits of the Southeastern States: U.S. Geol. Survey Prof. Paper, No. 335, 121 p.

Guidroz, Ralph R., and Mann, Virgil I., 1961, Gravity features along the western edge of the Slate Belt, North Carolina: Paper presented at S.E. Sect. of G.S.A., Knoxville, Tennessee.

Hurst, Vernon J., 1959, The geology and mineralogy of Graves Mountain, Georgia: Ga. Geol. Survey, Bull. 68, 33 p.

Kesler, Thomas L., 1936, Granitic injection processes in the Columbia Quadrangle, South Carolina: Jour. Geol., v. 44, p. 32-45.

King, Philip B., 1955, Guides to Southeastern Geology: Guidebook for 1955 Meeting of Geol. Soc. Am., p. 346-350.

Laney, Francis Baker, 1910, The Gold Hill Mining District of North Carolina: N.C. Geol. Survey, Bull. 21, 137 p.

Mann, Virgil I., 1961, Iron formations in the Southeastern States: Econ. Geol., v. 56, p. 997-1000.

McCauley, John F., 1959, The Carolina Slate Group and Charlotte Belt in Newberry County, South Carolina: Geol. Soc. Amer. Bull., v. 71, p. 2021.

McCauley, John F., 1960, A preliminary report on the gabbros of Newberry County, South Carolina, Geologic Notes; Div. Of Geol., S.C. State Dev. Board, v. 4, p. 41-43.

McCauley, John F., 1961, Rock analyses in the Carolina Slate Belt and the Charlotte Belt of Newberry County, South Carolina: Southeastern Geology, in press.

O'Rourke, J.E., 1961, Paleozoic banded iron-formations: Econ. Geol., v. 56, p. 331-361.

Overstreet, W.C., and Bell, Henry, 1960, Notes on the Kings Mountain Belt in Laurens County, South Carolina: Geologic Notes, Div. of Geol., S.C. State Dev. Board, v. 4, p. 27-30.

Smith, L.L., and Newcome, Roy, Jr., 1951, Geology of kyanite deposits at Henry Knob, South Carolina: Econ. Geol., v. 46, p. 757-764.

Mileage	Distance	
000.0	-	Holiday Inn Parking Lot, Cayce, S.C. Turn right (east) on Knox Abbott Drive.
000.1	00.1	First traffic light. Turn left (north) on State Street.
000.8	00.7	Traffic light. Turn left (west) on US-1.
000.9	00.1	Bay Service Station. Turn right (northwest).
001.3	00.4	Junction with US-378. Turn left (west).
003.4	02.1	Residual granite boulders on right (north) side of highway. These are weathered from a gray medium grained granite mass intrusive into the Carolina Volcanic-Sedimentary Group in the vicinity of Columbia. It is quarried south of the city for crushed stone.
004.1	00.7	Junction of I-26 and US-378. The roadcuts along this new highway were originally quite spectacular. Unfortunately they have been sprayed with a seed bearing tar and are now almost completely covered with a thick growth of grass.
007.2	03.1	First exposures of the Carolina Volcanic-Sedimentary Group. Excellent exposures of the Group are discontinuously exposed in the roadcuts along US-378 for approximately twenty miles. No detailed work has yet been done in this area.
010.5	03.3	Beginning of Coastal Plain embayment. The Tuscaloosa formation of Upper Cretaceous age is exposed in the roadcuts for the next 6.6 miles. The topography in this area is noticeably flatter than in the "Slate Belt".
011.4	00.9	Junction of SC-6 and US-378. Keep left on US-378.
013.1	01.7	Skating Rink on right side of highway. Keep right on US-378.
017.1	04.0	End of Coastal Plain embayment. The topography ahead is clearly more dissected.
018.5	01.4	Contact zone of medium grained gray granite intrusive into the Carolina Volcanic-Sedimentary Group. This pluton is entirely separate from that in the vicinity of Columbia. The contact zone here is only about 0.1 mile in width. It consists of schists and gneisses upgraded from the normal phyllite country rock. These relatively narrow contact zones are typical of the "Slate Belt" intrusives. Residual boulders from this granite are exposed in the fields on both sides of the highway for the next several miles.
021.1	02.6	Upgraded "Slate" rocks on the west side of the pluton. "Slate Belt" rocks will now be exposed continuously to the Newberry County Line.
026.7	05.6	Saluda County Line.
029.8	03.1	Traffic circle. Turn right (north) on SC-391.
032.7	02.9	Little Saluda River.
034.1	01.4	Saluda River, Newberry County Line.
034.4	00.3	Dark brown (Tirzah type) soil characteristically developed on the more mafic units of the Carolina Volcanic-Sedimentary Group.

035.6 01.2 Junction of County Road 17 and SC-391. Turn left (north) on CR-17.

037.4 01.8 **STOP 1:** The outcrop in front of the small white house on the south side of the road exposes beds of the middle part of the Volcanic-Sedimentary Group. At this locality several thin beds of chlorite phyllite or semi-schist are interlayered with lighter colored sericite phyllite. Structurally the outcrop is located on the north limb of a small syncline and the bedding here strikes N. 70° E. and dips 50° S. Although not readily visible in the outcrop, this bedding is cut by a closely spaced rock cleavage which strikes in the same general direction and dips 50 degrees to the north. The lineation formed by the intersection of bedding and cleavage strikes N. 65° E. and plunges at 10 degrees. In thin section, the chlorite phyllite consists of angular quartz fragments generally elongated parallel to the bedding. These are interlayered with sericite and penninite. Recrystallization of the penninite has taken place along the cleavage, and minor displacements in this direction have caused micro-chevron folding.

Modal and chemical analyses of the chlorite phyllite are given by McCauley (1961) as sample 260-N. It has an unusually low alkali content and a rather high total iron percentage. In other respects it appears to be similar to the average oceanic basalt. It is inferred that the rock was originally a mafic tuffaceous sediment. Its unusual chemical composition is the result of the blending of mafic volcanic material with siliceous terrigeneous debris.

Turn around after visiting this outcrop and retrace route on County Road 17.

037.8 00.4 Unmarked blacktop road (County Road 231). Turn left (north).

038.8 01.0 **STOP 2:** Small outcrop on right (east) side of road in front of house. This exposure is also in the middle part of the Carolina Volcanic-Sedimentary Group. The beds strike N. 70° E. and dip vertically. A lineation formed by the elongation of mica stringers strikes S. 70° W. and plunges at 10 degrees. The exposure is not spectacular but is worthy of visitation because of the unusual composition of the rock exposed. It appears in hand specimen to be a gray phyllite more or less typical of much of this part of the section in Newberry County and elsewhere in the central South Carolina Piedmont. However, in thin section it is seen to contain almost twenty percent opaque material which was identified by x-ray and other methods as specular hematite. It is distributed in the form of ill defined stringers parallel to the foliation which alternate with stringers of angular quartz and layers of felty "white" mica. Epidote is a very minor accessory. Modal and chemical analyses of this rock along with a microscope sketch (262-N) are also given by McCauley (1961).

The chemical analysis indicates a silica percentage similar to that of the average ultrabasic rock. It has, of course, a high ferric iron content along with a high alumina and alkali percentage. The soda and potash in this rock are in the white mica which appears to be intermediate in composition between muscovite and paragonite. X-ray studies confirm the presence of a mineral with "D" spacings intermediate between the two types. Since this mica is optically indistinguishable from "normal sericite" it is possible that much of the white mica previously identified as sericite is this intermediate type.

The origin of the hematite in this rock is an interesting problem. Several recent papers have discussed the origin of Piedmont iron ores (O'Rourke, 1961; Mann, 1961); and considerable disagreement seems to exist, particularly in regard to their abundance. This occurrence is not strictly an iron ore but is similar to what has generally been described as "itabirite". The hematite is in the form of irregular stringers parallel to the bedding. The individual grains, although irregular in shape, do not exhibit any replacement textures. The writer suggests that the hematite was formed or deposited under sedimentary conditions in a basin composed of tuffaceous silts and shales.

After visiting this outcrop continue north on County Road 231.

041.5 02.7 Junction of County Roads 41 and 231. Turn left (west) on CR-41.

043.1 01.6 St. Lukes Lutheran Church. Junction of County Roads 17 and 41. Turn right (north) on CR-17.

043.5 00.4 **STOP 3:** A small quarry on the right (east) side of the road exposes rocks of the lower-most portion of the Volcanic-Sedimentary Group. Here light colored felsic volcanics are interbedded with thin, mafic tuffaceous sediments. These are both intruded or possibly replaced by coarse grained granitic sills and small dikes which locally cross-cut the foliation.

The attitude here is N. 70° E., 60° S. and the structural position is the southeastern limb of the Charlotte Belt anticlinorium. Stratigraphically this exposure is several thousand feet downsection from the rocks at Stops 1 and 2.

Exposures of this type are present all along the western margin of the "Slate Belt" and are interpreted to represent the transition from shallow level rocks of the "Slate" type to the deep seated plutonics of the Charlotte Belt. Thus the "Slate Belt" rocks in this area grade stratigraphically downward from shallow water volcanic-sedimentary rocks into deeper water submarine basalts and graywackes or the Charlotte Belt. This contact is considered to be essentially conformable and the two groups of rocks simply represent different levels of geosynclinal accumulation.

After this stop proceed northward on County Road 17 to the intersection with a dirt road.

044.2 00.7 Dirt road intersection. Turn around and retrace route on CR-17 to St. Lukes Church.

045.4 01.2 St. Lukes Lutheran Church. Turn left (east) on County Road 41.

048.0 02.6 Junction of County Road 41 and SC-391. Continue straight ahead on CR-41. Topographically this is the highest area in Southwestern Newberry County and is part of the belt of hills in excess of 600 feet which marks the northwestern edge of the "Slate Belt".

049.9 01.9 Junction of county Roads 26 and 41. Turn right (south) on CR-26.

051.3 01.4 Junction of County Roads 72 and 26. Bear left (southeast) on CR-72.

052.9 01.6 Junction of County Roads 211 and 72. Turn left (north) on CR-211.

053.1 00.2 **STOP 4:** This exposure along the right (east) side of the highway exhibits the character of the structural deformation within the "Slate Belt". The rocks are sheared tuffaceous sediments composed of quartz, white mica and epidote. Slight compositional differences show that the original bedding is at a distinct angle to the cleavage. This cleavage is parallel to the axial planes of several small folds which are asymmetrical to the northwest. As at Stop 1 the intersections of these two surfaces cause the rock to break into "pencil like" fragments. Although some exceptions have been noted the asymmetry of the folding throughout Newberry County is to the northwest, both in the Charlotte Belt as well as the "Slate Belt".

After this stop continue north on CR-211.

056.0 02.9 Junction of US-76 and County Road 211. Turn right (south). Between here and the town limits of Little Mountain a good view of the monadnock can be had. The smaller ridge to the northwest is called Cannon Hill. It is separated from Little Mountain by a valley, and the kyanite quartzite beds that form the steeper north face are offset about one half mile to the north. A major N. 20° W. trending fault is present in this valley. Small notches can be seen along the crest of Little Mountain. These are the locations of smaller cross faults which offset the quartzite beds on Little Mountain itself.

057.6 01.6 Junction of County Road 73 and US-76. Turn right (south).

057.8 00.2 Turn right on unmarked black top road to crest of Little Mountain.

058.6 00.8 **STOP 5:** Parking area at east end of Little Mountain. In the woods at the north side of the parking area a ledge of kyanite quartzite crops out. The kyanite is present in the form of small disseminated poikilitic grains, coarsely crystalline elliptical pods, and irregular stringers composed almost exclusively of kyanite. These disseminated grains, pods, and stringers of kyanite are generally oriented parallel to the bedding but isolated crosscutting kyanite veins are present. A modal analysis of the disseminated type quartzite gives the following values: quartz 83%, sericite and pyrophyllite 5%, kyanite 11%, pyrite 1%. The pyrophyllite is present as an alteration product of the kyanite and locally occurs in the form of well developed rosettes.

The kyanite beds at this position strike about N. 70° E. and dip 60° S. An inclined drill core at the north edge of the parking area penetrated several hundred feet of quartzite separated by thinner beds of muscovite and chlorite schist. These beds of kyanite quartzite are offset at a number of places along the length of the mountain by northwest trending cross faults, the larger of which occupy the notches along the length of the mountain.

The origin of kyanite deposits of this type has received considerable recent attention. Smith and Newcome (1951) suggested a hydrothermal origin for the similar deposits at Henry Knob, S.C. Hurst (1959) has recently suggested a metamorphic origin for the kyanite occurrences at Graves Mountain, Georgia. He postulates that the kyanite grew under water deficient conditions at 400 to 500°C and at high pressure. The pyrophyllite is inferred to have formed by the ingress of water along fractures as the rocks began to cool. Espenshade and Potter (1960) studied numerous similar and dissimilar deposits throughout the Southeastern States. They considered the bedded type deposits to originate by metamorphism of aluminous sedimentary rocks. Included in this category are the deposits at Farmville, Virginia, and those of the Kings Mountain district, North and South Carolina. Other deposits of a less obviously bedded nature were classified as being of hydrothermal replacement origin. These include the topaz-rich deposits at the Brewer Mine, S.C.; the kyanite-quartzite deposits at Hagers Mountain, N.C.; Little Mountain, S.C.; and Graves Mountain, Georgia. The writer suggests that these last two deposits are misclassified and should be included under the heading of metamorphic bedded deposits, probably forming under physical conditions close to those suggested by Hurst (1959).

LUNCH

After this stop turn around and return to US-76 by the same route.

059.6 01.0 Junction of US-76 and County Road 73. Turn right and then left on dirt road over railroad tracks.

059.6500.05 Junction of dirt road with County Road 39. Turn right (south) on CR-39.

062.2 02.55 Junction of I-26 and County Road 39.

063.5 01.3 Junction of US-176 and County Road 39. Turn right (south) on CR-39.

064.7 01.2 Junction of SC-213 and US-176. Turn right (east).

066.8 02.1 Stop sign. Bear left, continuing on SC-213.

067.4 00.6 Entrance to Pinner's Bridge. Turn right (east) on SC-213 toward bridge.

067.6 00.2 **STOP 6:** Deep roadcut into hornblende gneiss typical of the original Charlotte Belt country rock. Hornblende gneiss of similar composition has been discussed by McCauley (1961), sample 232-N. These rocks vary from massive to well banded but generally show only a weakly banded texture. In thin section, the rock consists of alternating layers of hornblende, clino-pyroxene, and plagioclase. The clino-pyroxene is diopsidic in composition and the plagioclase ranges around An30.

Chemically these rocks show a close similarity to the average basalt and are quite distinct in composition from the mafic units of the "Slate Belt". Essentially the chemical differences are that the hornblende gneiss is significantly lower in silica, iron and alumina while it is higher in lime, magnesia and soda. These differences and the fact that mafic rocks are generally more abundant in the Charlotte Belt has led to the conclusion that the Charlotte Belt amphibolites and hornblende gneisses are not higher rank metamorphic correlatives of the "mafic slates". It is believed that they represent a deeper water accumulation of submarine basalts and graywackes now exposed in the core and on the flanks of the Charlotte Belt anticlinorium.

This exposure exhibits intrusive rocks of three distinct ages and compositions. The youngest are the fine to medium grained unmetamorphosed dikes of Triassic (?) diabase. The next youngest are the mutually crosscutting dikes of granitic composition. Some of these dikes exhibit foliation and are deformed and faulted. Other are unfoliated and appear to have been emplaced very late in the orogenic cycle. These dikes show little reaction with the hornblende gneiss except for the development of an inch to two of biotite on either side of the contact. This biotite is inferred to have formed at the expense of the hornblende in response to a "wet" environment at the margins of the dikes. This is considered as evidence that the regional metamorphism of the submarine basalts preceded the main period of granitic intrusion. The oldest dikes are mafic in character and extensively chloritized. These dikes also show little effect on the hornblende gneiss and it is believed they were emplaced during the waning stages of regional metamorphism.

After visiting this outcrop turn around and retrace route.

067.8 00.2 Junction of SC-213 and County road 28. Turn right (north).

070.6 02.8 **STOP 6A:** (Optional): A shallow roadcut on the east side of the road exposes hornblende gneiss of the same general type as at Stop 6. However, here the gneiss is more intimately injected with granitic dikes. As the major granitic plutons in the central part of the county are affroaached, the number and size of these dikes increases, along with an increase in the amount of biotite. In addition, partial or almost complete assimilation of the country rock takes place along the contacts and within the plutons.

072.3 01.7 **STOP 7:** Junction of County Roads 98 and 28. Turn left (west) on CR-28 and park in the most convenient place, as far off the road as possible.

This stop exhibits large residual boulders of coarse grained buff colored quartz monzonite. Extensive bodies of rock of this type appear in this east-trending prong of the Newberry pluton and as smaller isolated bodies along the margins of the larger granitic mass. A very similar rock (184-N) has been discussed by McCauley (1961). The rock contains a modest hornblende percentage as well as a substantial biotite content. Chemically it is more intermediate in composition than the gray medium grained granite characteristic of the main parts of the pluton (Stop 9). The hornblende content and the more intermediate composition are attributed to assimilation of the hornblende gneiss country rock to an extreme degree. In support of this view small disoriented hornblende and biotite rich zenoliths can be seen scattered throughout several of the boulders.

After this stop continue east on CR-98.

076.6 04.3 Stop sign at junction of Country Roads 97 and 98. turn left on CR-97.

077.6 01.0 Junction of US-176 and Country Road 97. Turn right into parking lot of Bonner's Café. **Rest and Refreshment Stop.**

Upon leaving café turn left (south) on US-176.

078.6 01.0 Historical marker on right side of highway, dirt road on left. Turn left (east) onto dirt road which is the entrance to the Pomaria Quarry. On the right side of the road a good exposure of hornblende gneiss can be seen just above the pond also on the right.

079.0 00.4 **STOP 8:** This quarry was opened in 1958 and abandoned the following year. It was utilized chiefly to supply crushed stone for the new I-26 Interstate Highway. It straddles the contact between Charlotte Belt gneiss and the relatively massive granitic rocks exposed to the north. Mafic gneiss typical of the Charlotte Belt can be seen in the south wall. Mafic zenoliths are common in the quarried area along with banded and contorted migmatites. This type of contact is characteristic of the granite bodies in the Charlotte Belt. It is very difficult to demarcate between the migmatitic country rock and the granite itself. The transition zone in some cases is several miles in width. The criterion used in the Newberry Bounty mapping was the loss of banding and well developed foliation within the granite areas.

Turn around and return to US-176.

079.4 00.4 Junction of Quarry entrance road with US-176. Turn right (north).

086.5 07.1 Junction of SC-34 and US-176. Turn left (west) on SC-34.

090.1 03.6 **STOP 9:** Pull off the road as far as possible. This is a fairly well traveled route. A number of small dimension stone quarries are present in the trees to the north of the road. The rock here is a medium grained gray granite considered typical of the major portion of the pluton centered north of the city of Newberry. This granite has been described by McCauley (1961) as specimen 284-N. Chemically and petrologically it is a typical granite although its gray color lends one to suspect that it might be somewhat more intermediate in composition.

A weakly developed foliation is present which strikes north-south and dips east. These faint structures within the central parts of the pluton are attributed to flowage rather than to unreplaced relicts of the country rock.

After this stop continue west on SC-34.

093.5 03.4 **STOP 10:** Again, please pull off road as far as possible. A thin dike of purplish green, coarse grained, amphibole gabbro is exposed on the north side of the cut. This rock has been described by McCauley (1960; 1961). The term hornblende gabbro used in Figure 1 is a misnomer. It is essentially a retrogressively altered gabbro composed of well twinned plagioclase and fibrous amphiboles of the tremolite-actinolite type. Some clino-pyroxene is present along with chlorite and biotite. The composition of the plagioclase is An50. Its chemical composition is close to that of the average plateau and tholeiitic basalts.

This rock is part of a thin (20-200') crescent shaped dike which has bee traced by means of relatively fresh boulder outcrops a distance of about four miles. The dike apparently dips in toward the center of the crescent and may fit the definition of a cone sheet. Larger more irregularly shaped plugs of similar rock are exposed to the west of the town of Newberry.

These rocks are cut in places by pegmatite dikes which indicate that some granitic activity postdated their emplacement. This late stage granitic activity was responsible for the retrogressive metamorphism here present.

Field trip participants have a choice of route in returning to Columbia. Some may wish to utilize I-26 which can be entered just beyond Stop 9. Others may prefer to return via Route 76, one half mile west of this point. The road log continues along Route 76 and several points of interest in the Irmo Quadrangle are noted.

094.1 00.6 Junction of US-76 (bypass) and SC-34. Turn left (south) on US-76.

107.1 13.0 Lexington County Line.

111.2 04.1 Richland County Line.

116.1 0.49 Junction of SC-6 and US-76. Turn right (west) on SC-6.

117.0 00.9 Road cut exposures of upgraded volcanics of the “slate” group. This area is part of the Irmo Quadrangle (Heron and Johnson, 1958).

117.9 00.9 Richland County Line.

122.5 04.6 Lake Murray Spillway. Excellent fresh exposures are present at the bottom of the Spillway. This area was visited during the 1958 Carolina Geological Society Trip. Hornblende gneisses and granites are present well within the margins of the Slate Belt in this area. Some of these are related to the many scattered intrusives located within the quadrangle. However, some of this high rank metamorphic rock is related to an anticlinal structure which apparently brings up the stratigraphically lower Charlotte Belt rocks.

122.9 00.4 Junction of County Road 68 and SC-6. Turn left (east).

126.7 03.8 Guignard Clay Pit. Excellent exposures of the Carolina Volcanic-Sedimentary Group. This locality was also visited on the 1958 Carolina Geological Society Trip.

128.1 01.4 Junction of US-378 and CR-68. Continue straight ahead on US-378, and return to Holiday Inn.

134.8 06.7 Holiday Inn Parking Lot.

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FALL LINE STRATIGRAPHY NORTHEAST OF COLUMBIA, S.C.

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Overlying crystalline rocks of the Carolina Slate Belt in the Fall Line Zone near Columbia, S.C., are kaolinitic sands and clays of the Tuscaloosa Formation of Upper Cretaceous age; varicolored laminated clays and red sands of undifferentiated Tertiary age; Post-Eocene eolian and water deposited sands; and lesser terrace and floodplain sand and gravel deposits of Pleistocene age. The principal mineral resources of the Fall Line Zone are granite (crushed stone), shale (brick and pipe), kaolin (brick and pipe), clayey sand (road material), and high silica sand (foundry and glass sand). This field trip is aimed at getting acquainted with Fall Line geology, with emphasis on the Post-Eocene sand deposits. It is expected that persons taking this trip will also be provided with a copy of the geologic map of the Fort Jackson North quadrangle (Pooser and Johnson, 1961).

ROAD LOG

Distance	Mileage	
0.0	0.0	Assemble at Holiday Inn Motel parking lot, Cayce, S.C. Turn right (E) on Knox Abbott Drive.
0.1	0.1	Intersection of Knox Abbott Drive and State Street. Continue east on Knox Abbott Drive.
0.4	0.5	Guignard Brick Works on the left. This is probably the oldest brick plant operating today in the United States. Production of brick from local river clays began here about 1800 and except for a minor shutdown caused by General W.T. Sherman in 1865 has continued uninterruptedly to the present. In 1951 the plant switched from river clay to shale from Carolina Slate Belt deposits a few miles to the west. The tunnel kiln was put in operation in 1956.
0.1	0.6	Congaree River. Note granite boulders exposed in the bed of the river at low water. This granite is presently quarried for crushed stone at the Weston-Brooker and Palmetto quarries, on both sides of the river about a mile south. The floors of these quarries are now about 100 feet below sea level. The granite is intrusive into rocks of the Carolina Slate Belt.
0.4	1.0	Traffic light. Turn left (N) on Huger Street. Note red loess-like deposits on clayey sand in the ditches over the next mile or so. This unit is present over much of the Columbia area. I regret to say that it is like the weather. Everybody talks about it but nobody does anything about it. I really don't know what it is. I can only speculate that it may be a Pleistocene estuarine deposit or possibly a strongly developed paleosol.
0.6	1.6	Traffic light. Intersection of Huger and Gervais Streets. Continue north on Huger.
0.8	2.4	Highway Interchange. Bear right (E) on Elmwood Avenue.
0.3	2.7	Overpass. Note red loess-like unit in railroad cut. Continue east on Elmwood Avenue.
0.5	3.2	Intersection Elmwood Avenue and Main Street. Continue east on Elmwood.
0.3	3.5	Intersection Elmwood Avenue and Bull Street. Turn left (N) on Bull.
0.3	3.8	Intersection Bull Street and Colonial Drive. Turn right (E) on Colonial Drive.
0.3	4.1	Cross-bedded kaolinitic sands of the Tuscaloosa Formation (Upper Cretaceous) crop out in the roadside ditches.
0.4	4.5	Intersection Colonial Drive, Harden Street, and Farrow Road. Continue straight through on Farrow Road.
0.2	4.7	Columbia City Limit.
0.3	5.0	Intersection of Farrow Road and Sunset Drive – Beltline Boulevard. Continue straight through on Farrow Road.
0.2	5.2	Tuscaloosa Formation exposed in roadside ditches.
0.8	6.0	Bendale town limit.
1.2	7.2	Railroad underpass. Tuscaloosa Formation exposed in railroad cut and in roadside ditches.
0.5	7.7	Intersection of Farrow Road and Fontaine Road. Turn right (SE) on Fontaine Road.
0.5	8.2	Typical Tuscaloosa Formation exposed in road and railroad cuts along here.
0.4	8.6	Intersection of Fontaine Road, Shakespeare Road, and U.S. 1. Turn 90° left (N) on Shakespeare Road.
0.1	8.7	Turn left on dirt mine access road (at No Trespassing sign).

0.3 9.0 **STOP 1.** Strickland Sand Pit. The section in this pit troubles me. Fairly typical Tuscaloosa Formation is exposed in the deeper workings. At the top of the north wall of the pit is about 5 to 15 feet of sand which seems to truncate the lower beds and correlates well with the predominantly eolian Post-Eocene Sand unit, which is well developed in part of the Fort Jackson North quadrangle. Between these two units, however, is 30 to 40 feet of sands which appear to be younger than the Tuscaloosa Formation and which are more clayey than the overlying eolian sand and contain sparse quartz and ironstone pebbles, scour and fill structures, fluvial or marine cross-bedding, and blebs of white kaolin. It is not clear to me whether this middle unit is an atypical phase of the Tuscaloosa Formation, a water deposited phase of the Post-Eocene Sand unit, or something else again. Whatever it is, it doesn't seem to be mappable as a separate unit outside of artificial exposures. Circle through sand pit and return to entrance on Shakespeare Road.

0.3 9.3 Intersection of Strickland Mine road and Shakespeare Road. Turn left (N) on Shakespeare Road.

0.3 9.6 Post-Eocene Sand unit exposed along road for the next mile. Note typical Sandhills terrain off to the east. The higher ridges are commonly capped by the Post-Eocene Sand unit.

1.2 10.8 Tuscaloosa Formation exposed in roadside ditches.

0.1 10.9 Intersection of Shakespeare Road and U.S. 1. Turn left (NE) on U.S. 1.

2.2 13.1 Weddell. The original hilltop on the left side of the road here has been removed to prepare a business site. The excavation exposes typical Tuscaloosa Formation overlain by 0-5 feet of eolian (?) sand of the Post-Eocene Sand unit. Note that the top of the Tuscaloosa here is at an elevation of about 365 feet. Continue northeastward on U.S. 1.

0.4 13.5 On the left of the road at this point is a small sand pit in the predominantly eolian Post-Eocene Sand unit. This is typical of many small sand pits in this formation along the inner edge of the Coastal Plain. The sand is used locally for construction and miscellaneous purposes with no treatment other than simple screening for sizing. The top of the Tuscaloosa here is at an elevation of about 300 feet, about 65 feet lower than at mile 13.1. The Post-Eocene Sand unit here appears to have been deposited on the northeast side of a Tucaloosa hill. This, together with the eastward dip of the steeper (34°) crossbeds, suggests that the sand was deposited by prevailing westerly winds. Continue northeast on U.S. 1.

0.2 13.7 Typical Tuscaloosa Formation exposed in railroad cut.

1.0 14.7 Railroad underpass. Tuscaloosa Formation exposed in cuts. The high ridge across the valley to the left (northwest) is capped by eolian sand of the Post-Eocene Sand unit.

0.8 15.5 Turn right (E) on unnumbered dirt road. Post-Eocene Sand unit exposed in road cut.

0.4 15.9 Contact between Post-Eocene Sand and the Tuscaloosa Formation. The overlying sand drapes down the hillslope and obscures the contact. It can best be seen after a rain, when water emerges in the ditches at the point where the less permeable Tuscaloosa Formation intersects the surface.

0.5 16.4 Note kaolin bed (Tuscaloosa Fm.) cropping out in roadside ditch. This kaolin is mined in the pit on the right side of the road at this point.

0.1 16.5 **STOP 2.** Kaolin from this pit is used locally in the manufacture of firebrick and light colored face brick. The exposure in the north wall of the pit shows impure kaolin overlain by 8 to 10 feet of cross-bedded kaolinitic sand (typical Tuscaloosa Fm.) overlain by 0-5 feet of eolian (?) sand of the Post-Eocene Sand unit. Continue south on unnumbered dirt road.

0.4 16.9 Turn left (E) on unnumbered dirt road. Typical "Sandhills" terrain for the next several miles. This is predominantly eolian sand of the Post-Eocene Sand unit.

0.6 17.5 Turn left (NE) on unnumbered dirt road.

0.2 17.7 To the right (E) is the entrance to the University of South Carolina YMCA Camp. Continue straight ahead (NE) on unnumbered dirt road.

0.2 17.9 Ignore side roads. Continue straight ahead (NE).

1.3 19.2 Intersection. Bear left (N) on unnumbered dirt road.

0.8 20.0 Relative lushness of vegetation in this depression indicates the less permeable Tuscaloosa Formation is within a few feet of the surface at this point. The dryer surrounding hills are composed of the very permeable Post-Eocene Sand unit.

0.4 20.4 Intersection. Continue straight ahead (NW) on unnumbered dirt road.

0.3 20.7 Note dune topography of the Post-Eocene Sand unit in this area.

0.4 21.1 Intersection of dirt road and U.S. 1. Turn right (NE) on U.S. 1. Note dune topography along the highway for the next several miles. This is the Post-Eocene Sand unit.

1.7 22.8 Town of Pontiac. Continue on U.S. 1.

2.7 25.5 Kershaw County Line.

1.8 27.3 Blaney town limit.

0.5 27.8 Center of Blaney. Turn right (SE) on County Road 28-50.

0.1 27.9 Intersection. Turn left (E) on County Road 28-47.

0.2 28.1 Post-Eocene Sand unit well exposed on hillside and in cuts in this area.

0.7 28.8 Turn left on unnumbered dirt access road to White Pond.

0.1 28.9 **STOP 3.** White Pond. This is one of the few natural ponds in central South Carolina. The presence of the relatively impermeable Tuscaloosa Formation a few feet below the surface causes water to stand in this natural depression in the highly permeable Post-Eocene Sand unit. Wave action has tended to round out the shore line and to clean and sort the sand along the beach. Continue on dirt road back to CR 28-47.

0.1 29.0 Intersection of White Pond access road and County Road 28-47. Turn left (E) on CR 28-47.

1.7 30.7 Intersection. Continue straight through on County Road 28-47.

0.2 30.9 Kaolin bed (Tuscaloosa Fm.) exposed in roadside ditch.

0.6 31.5 Kaolin bed (Tuscaloosa Fm.) exposed in roadside ditch.

0.3 31.8 Intersection County Road 28-47 and S.C. Highway 12. Turn left (NE) on S.C. Highway 12. Tuscaloosa Formation exposed in road cuts for the next several miles.

3.5 35.3 **STOP 4.** Kershaw Sand Pit. This is one of the better exposures of the Post-Eocene Sand unit. The Tuscaloosa Formation was encountered at an elevation of about 280 feet (approximately 10 feet below highway level) in the deepest part of the pit. The Post-Eocene Sand unit in this exposure is thought to have been deposited largely by wind. The steep (34°) eastward dipping beds in the lower half of the pit were probably deposited on the lee slope of dunes. The flatter beds which overlie and truncate the steeply dipping ones were probably deposited on the windward side of dunes or in broad inter-dune areas. The clay-rich beds near the middle of the pit wall are thought to have been deposited in shallow inter-dune ponds or lakes. Leave S.C. Highway 12 and proceed north-northwest on unnumbered dirt road along south edge of the sand pit.

0.6 35.9 On the right in the distance can be seen the Whitehead Brothers Company foundry sand operation. The ridge you are riding on constitutes the long range sand reserve for the Whitehead operation. The Post-Eocene Sand unit is about 100 feet thick at this point.

1.2 37.1 Road intersection. Turn right (N) on unnumbered dirt road.

1.1 38.2 Road intersection. Turn right (E) on access road to Whitehead Brothers Company plant.

0.5 38.7 **STOP 5.** Whitehead Brothers Company foundry sand plant.

This is the end of the trip. To return to civilization, follow the paved road 1.4 miles out to U.S. 1. At that point turn right to Camden and points north and east or left to Columbia and points south and west.